DB # 798

File copy
Holder 21

LAMONT-DOHERTY GEOLOGICAL OBSERVATORY

OF COLUMBIA UNIVERSITY

PALISADES, NEW YORK

T E C H N I C A L   R E P O R T

SPONSORED BY THE INTERNATIONAL PHASE OF OCEAN DRILLING
SITE SURVEY MANAGEMENT

NSF-C-482-2 IPOD Scope I

CU-1-78

*

SITE SURVEYS OF THE WESTERN SITES

OF THE

PHILIPPINE SEA TRANSECT OF IPOD DRILLING

*

M. G. Langseth

*

September 1, 1978

LAMONT-DOHERTY GEOLOGICAL OBSERVATORY

OF COLUMBIA UNIVERSITY

PALISADES, NEW YORK

T E C H N I C A L   R E P O R T

SPONSORED BY THE INTERNATIONAL PHASE OF OCEAN DRILLING
SITE SURVEY MANAGEMENT

NSF-C-482-2 IPOD Scope I

CU-1-78

*

SITE SURVEYS OF THE WESTERN SITES

OF THE

PHILIPPINE SEA TRANSECT OF IPOD DRILLING

*

M. G. Langseth

*

September 1, 1978

T E C H N I C A L   R E P O R T

SPONSORED BY THE INTERNATIONAL PHASE OF OCEAN CRILLING
SITE SURVEY MANAGEMENT

NSF-C-482-2 IPOD Scope I
CU-1-78

*

SITE SURVEYS OF THE WESTERN SITES OF THE PHILIPPINE SEA TRANSECT OF IPOD DRILLING

by

Marcus G. Langseth
September 1, 1978

Acknowledgements: We are grateful to Captain Henry C. Kohler and the crew of the Research Vessel VEMA and to the members of the scientific staff of Cruise 34, Leg 20 for their assistance. Ana Maria Dragonovic and Daniele Painter are responsible for many of the drawings and aided in the processing. Annette Trefzer contributed to the organization, proofing, as well as the typing. Dennis Hayes played a key role in organizing the work and in the discussion of the results.

T A B L E O F C O N T E N T S

*

*

SITE SURVEYS OF THE WESTERN SITES OF THE PHILIPPINE SEA TRANSECT OF IPOD DRILLING

M. G. Langseth

*

One of the major objectives of the Active Margin drilling during IPOD is a transect of holes running east-west across the Philippine Sea at latitude 18°N. This transect crosses from east to west the Mariana Trough (a back-arc basin) west of the island arc, the West Mariana Ridge, the Parece Vela Basin, the Parece Vela Ridge and the western part of the West Philippine Basin. The objectives of this transect of holes were multifold but cast in their most general terms, they were to sample oceanic basement where possible to determine its age and petrology, to determine the sedimentary history and structure for a better understanding of the evolution of the region and processes that shape its prominent features.

Eight drill sites have been planned to sample the major regions listed above. Holes will be drilled on two legs of the GLOMAR CHALLENGER. One leg will be devoted to sites on the western part of the transect and the other to sites on the eastern portion. To a large extent, site surveys in advance of drilling have been carried out in the same manner. The Hawaiian Institute of Geophysics has devoted two cruises to surveying sites east of the West Mariana Ridge, and L-DGO and SIO have done geophysical work over the western chain of sites. In addition, L-DGO made a multichannel seismic profile connecting all of the sites along the transect. This report describes geophysical surveys over five sites on the western end of the transects. This included sites on the West Mariana Ridge, the Parece Vela Ridge, two sites in the Parece Vela Basin and one in the eastern part of the West Philippine Basin.

These surveys were carried out on board the L-DGO research vessel R.V. VEMA in March and April, 1977. The ship's track is shown in Figure 1. The types of measurements made include 12 kHz and 3.5 kHz echosounding, continuous single channel seismic reflection profiling, magnetic field total intensity measurements and gravity measurements. Station work included piston cores (representative cores from each site have been sent to DSDP), dredging and heat-flow measurements. At all sites, several sonobuoy refraction profiles were made.

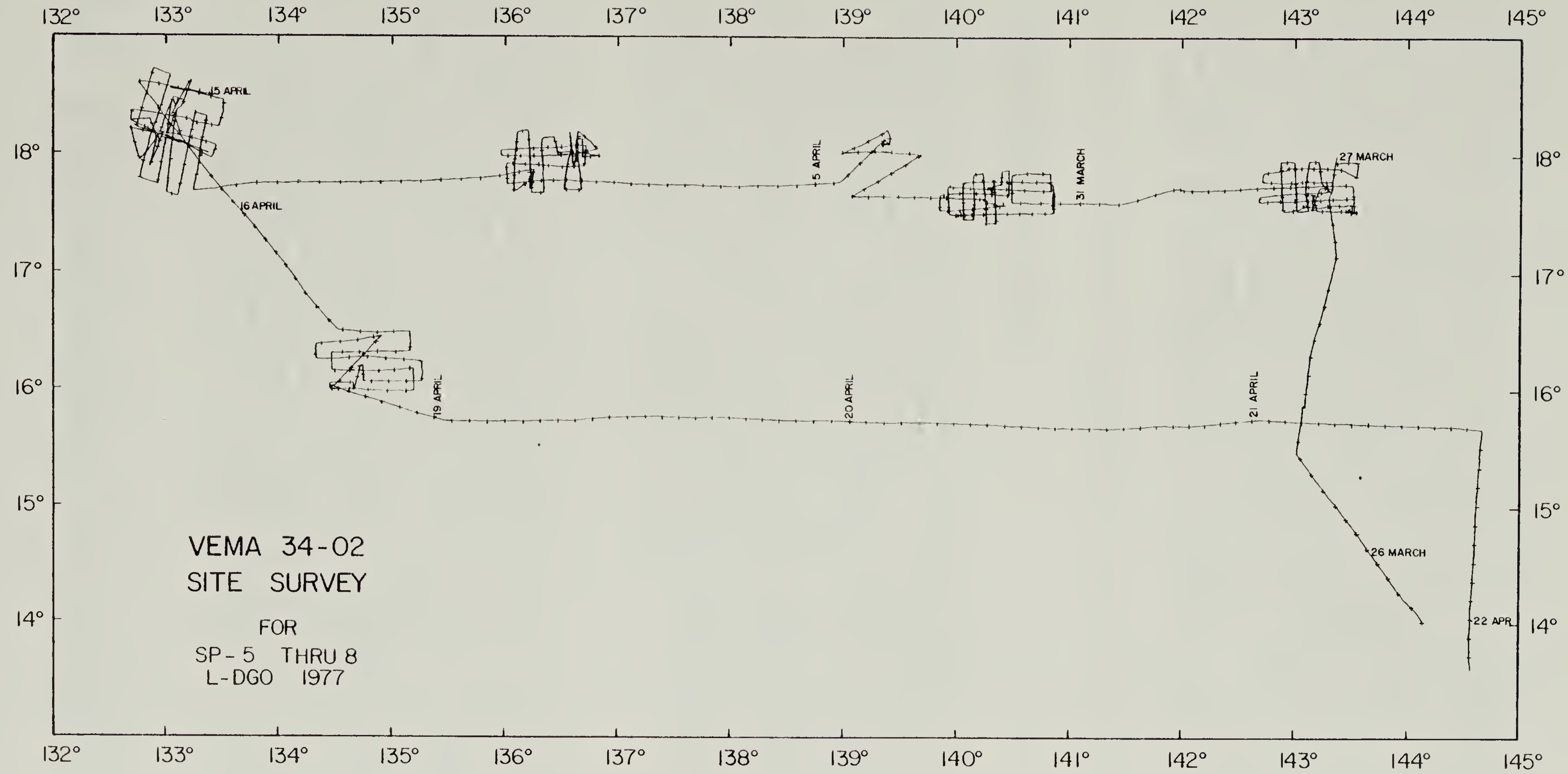


Figure 1

Track of VEMA 34, Leg 2. Left Guam on March 25, 1977 and returned to Guam on April 22, 1977

The principal features surveyed are well illustrated in the three long profiles shown in Figure 2 and have been described earlier by Karig (1971). On the right is the West Mariana Ridge with its steep eastward face and gently sloping western flank. The western flank is buried below a deep wedge of sediment that extends nearly 400 km into the Parece Vela Basin. The Parece Vela Basin is notable for its very rough high relief terrain. A discontinuous, very deep trough runs north-south near the center line of the basin. This feature may be an extinct spreading center. The Parece Vela Ridge in profile seems to be a deeper and narrower version of the West Mariana Ridge, with a sedimentary wedge again developed only on the western side of the ridge. The adjacent West Philippine Basin is characterized by the anomalous depth of its sea-floor and the relatively low relief of the basement topography.

What follows is a detailed description of the results of surveys at each site.

Site # 5 - The West Mariana Ridge

The West Mariana Ridge (also called the South Honshu Ridge) is a nearly continuous ridge trending northward from the southwestern end of the Mariana Trench to the Bonin Island Chain. It forms the western boundary of the Mariana Trough. The steep eastern face of the ridge drops with few interruptions to the floor of the trough. The relief along the crest of the ridge is great. In places flat top seamounts reach within 30 to 40 fms of the surface (55 to 73 m), and the tops of these seamounts were probably above water during the Pleistocene sea level lowering. The seamounts indicate island arc type volcanism played a role in forming the core of this ridge. At other places, deep wast-west trending troughs seem to cut across the ridge from flank to flank.

Bathymetry

The morphological complexity of the ridge is well illustrated in the 1/2° x 1° area surveyed just south of 18°N (Fig. 3 &4). In the southwest corner of the area, a steep sided, twin peaked volcanic seamount rises to within 45 fms (82 m) of the surface (Fig.5,Profile III). The eastern flank is equally complex, the characteristic asymmetric profile of the crest and steep eastern flank seen in profiles I and II in Figure 5 do not continue southward but seem to terminate in a general northwest-southeast trending depression that cuts across the ridge. The steep slope of the eastern face is often broken by ledges. The profiler traces show these ledges to be formed by ridges with small ponds of sediment trapped behind them. Some of the broader ledges, for example, those seen on profile V, Figure 5, may be an excellent place to try for basement rocks on the ridge.

Sediments

Except for the steep sided seamount, the crest of the ridge is draped with sediments. In the broad trough between the seamount and the ridge's

SEISMIC REFLECTION PROFILES ACROSS THE PARECE VELA BASIN

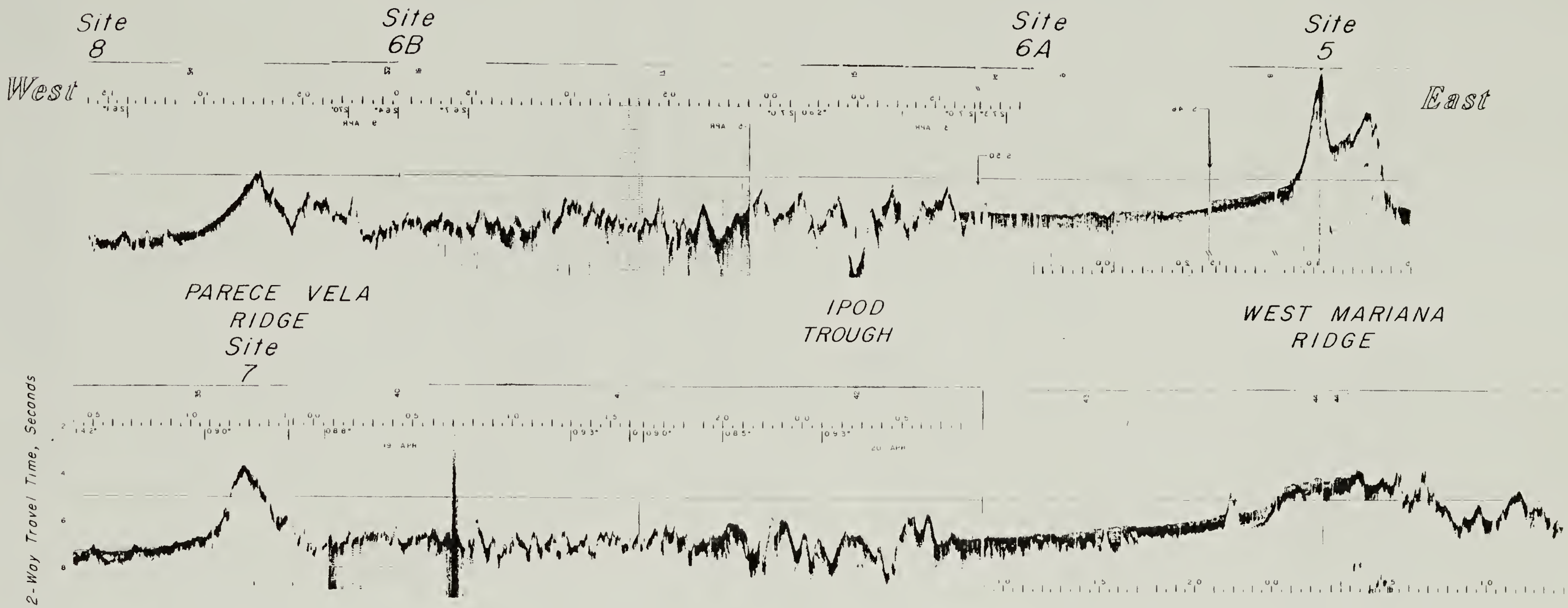


Figure 2

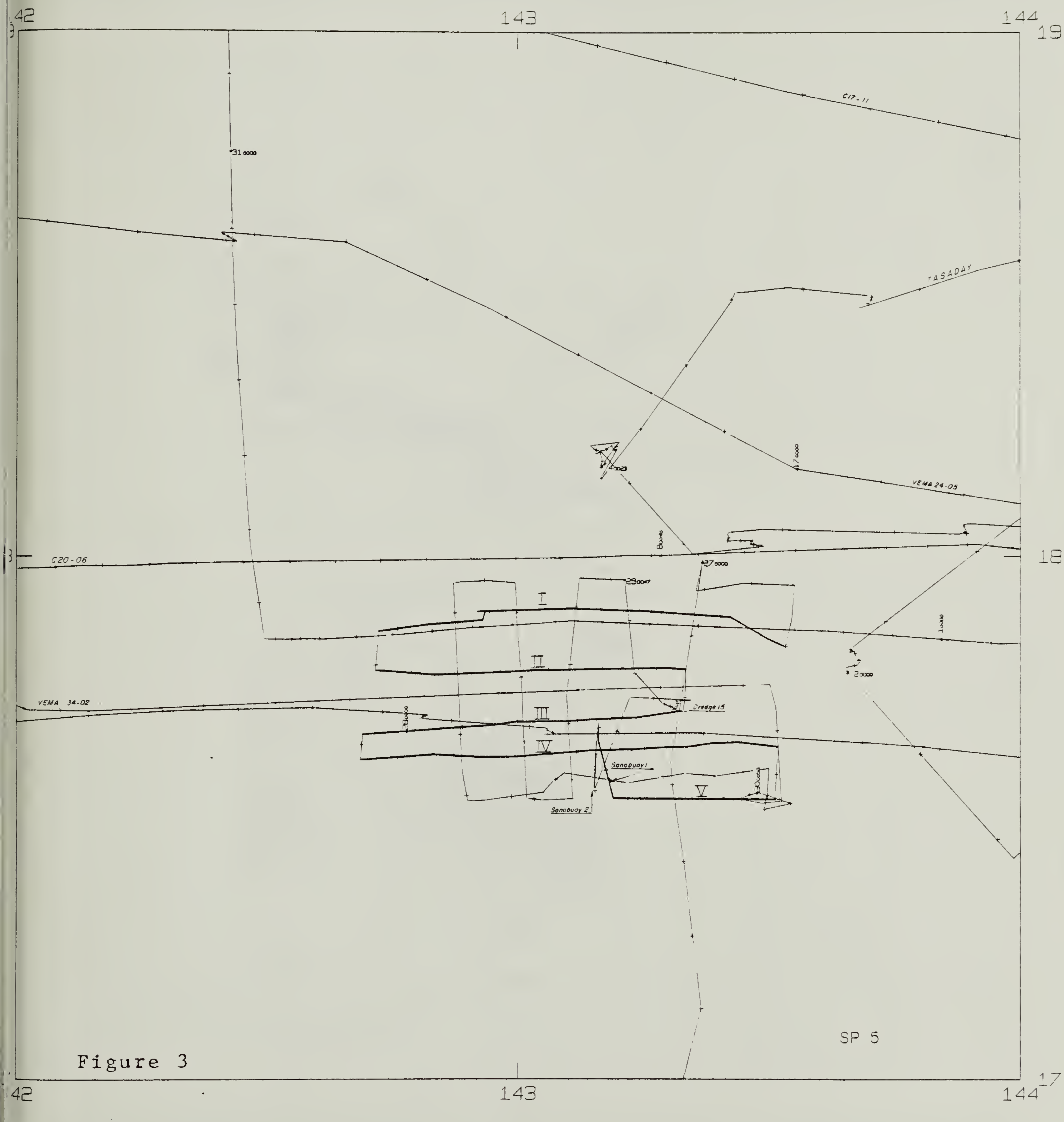


Figure 3

Track in the vicinity of Site #5 on the West Mariana Ridge. All of the tracks along which geophysical data are available are included. The heavily drawn east-west lines with Roman numerals correspond to profiles shown in Figure 5

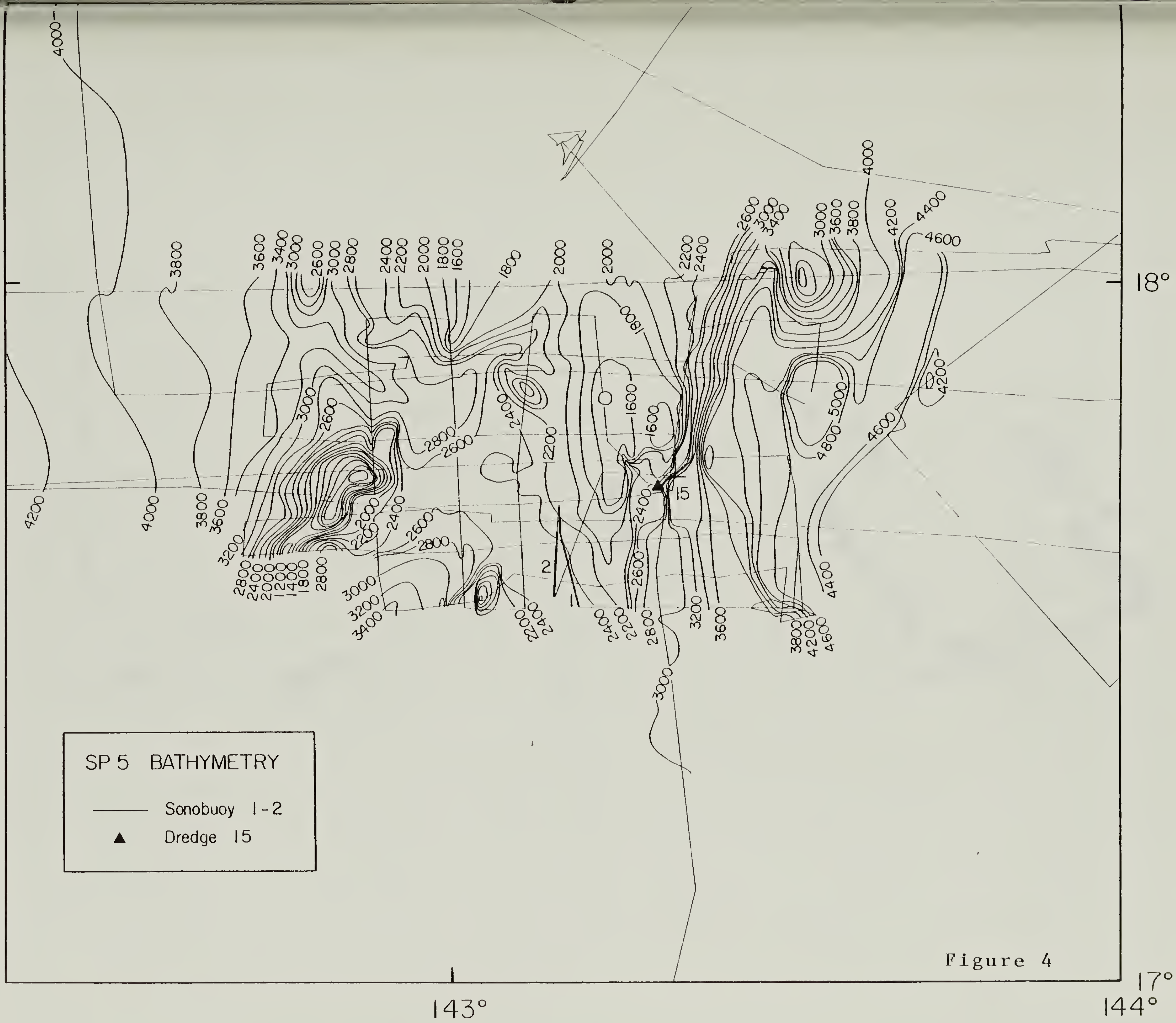


Figure 4

Bathymetry at Site #5. The depths are in corrected meters

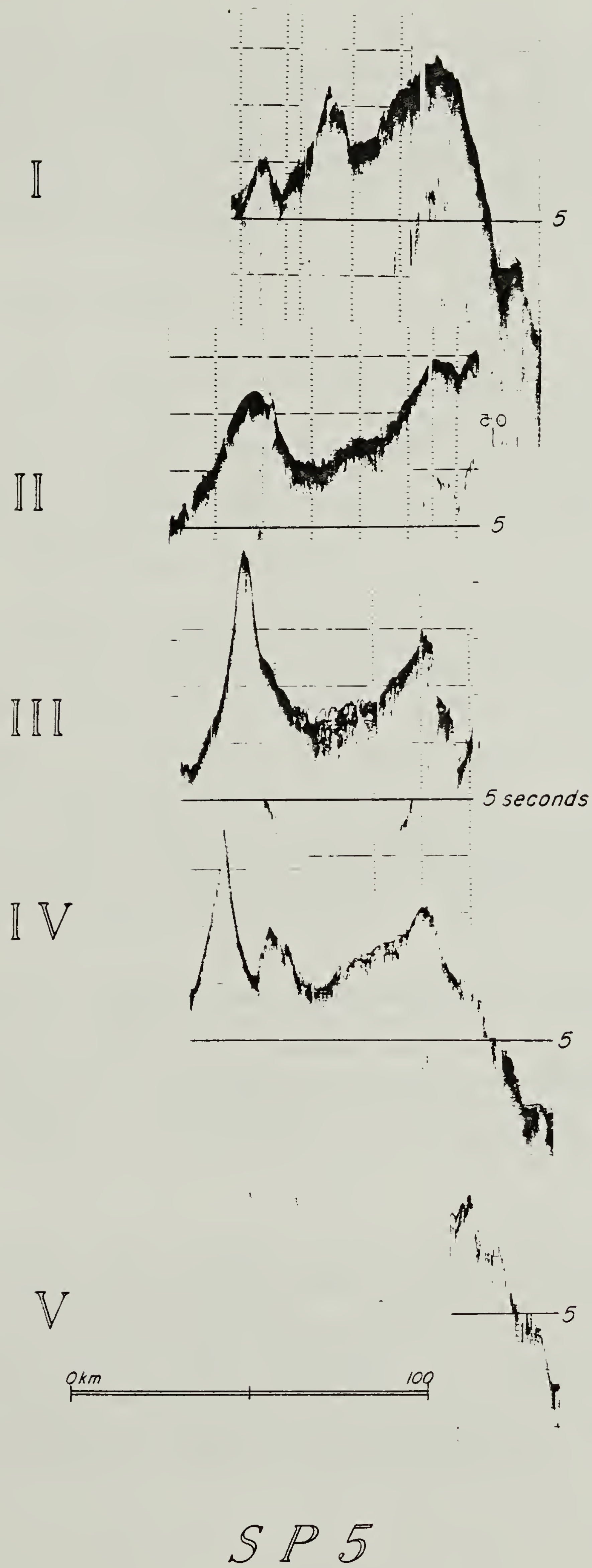


Figure 5

eastern crest the profiler records show that the sediment is deformed into folds and hummocks. This deformation may have resulted from recent tectonic movement. The sediments are relatively opaque and nowhere can we confidently identify the surface corresponding to the igneous core of the ridge. Only the layering in the upper few tenths of a second two-way reflection time is seen. The two refraction profiles described below indicate that the sedimentary cover is possibly one kilometer or more thick.

Seismic Refraction Studies

Two sonobuoy refraction profiles, running roughly north-south, were run over the crest of the ridge paralleling the main topographic trends of the ridge, Figures 3 and 6. The objective was to shoot these as reversed profiles; however, the ship drifted so rapidly with currents that the shooting lines diverge and they cannot be interpreted as reversed profiles. Rather high relief topography was encountered along the profiles; however, refractors were recorded and a rough indication of the ridge structure was obtained.

A one kilometer layer of low velocity material caps the crest of the ridge. This is probably sedimentary deposits. Clear reflections from the base of this layer were not obtained so that wide angle reflection determinations of the internal velocity were not made.

The layer is underlain by 4.2 km/sec material, which was observed as a refractor only at Profile 1, and is assumed to exist beneath Profile 2, although a clear refractor associated with this 0.6 to 0.8 km thick layer is not observed. The material composing this layer consists probably of volcanic flows and volcanoclastic materials forming the core of the ridge. A higher velocity layer (5.0-5.6)km/sec begins at 4.6 to 4.9 km below sea level.

The results indicate that thick sedimentary deposits would make drilling to the volcanic material at the core of the ridge very difficult. Thinner sediments north of the survey area were detected along the multichannel profile over the ridge and have been recommended as the best site to meet objectives. As we proposed above, one of the terraces on the steep eastern face may make another attractive target.

Dredges

Two dredges were attempted on the eastern face of the West Mariana Ridge. The deeper of the two yielded no rocks. Apparently, the dredge bucket encountered only sediments. A dredge up on a face, between two terraces at 1260 and 1570 fms (2306-2873 m), yielded a suite of highly weathered mafic rocks. Most were reduced to a light greenish-yellow chalk. Many chunks were covered with a thick rind of manganese and veins of manganite run through the altered blocks. Pumice fragments were another prominent component of the dredge haul.

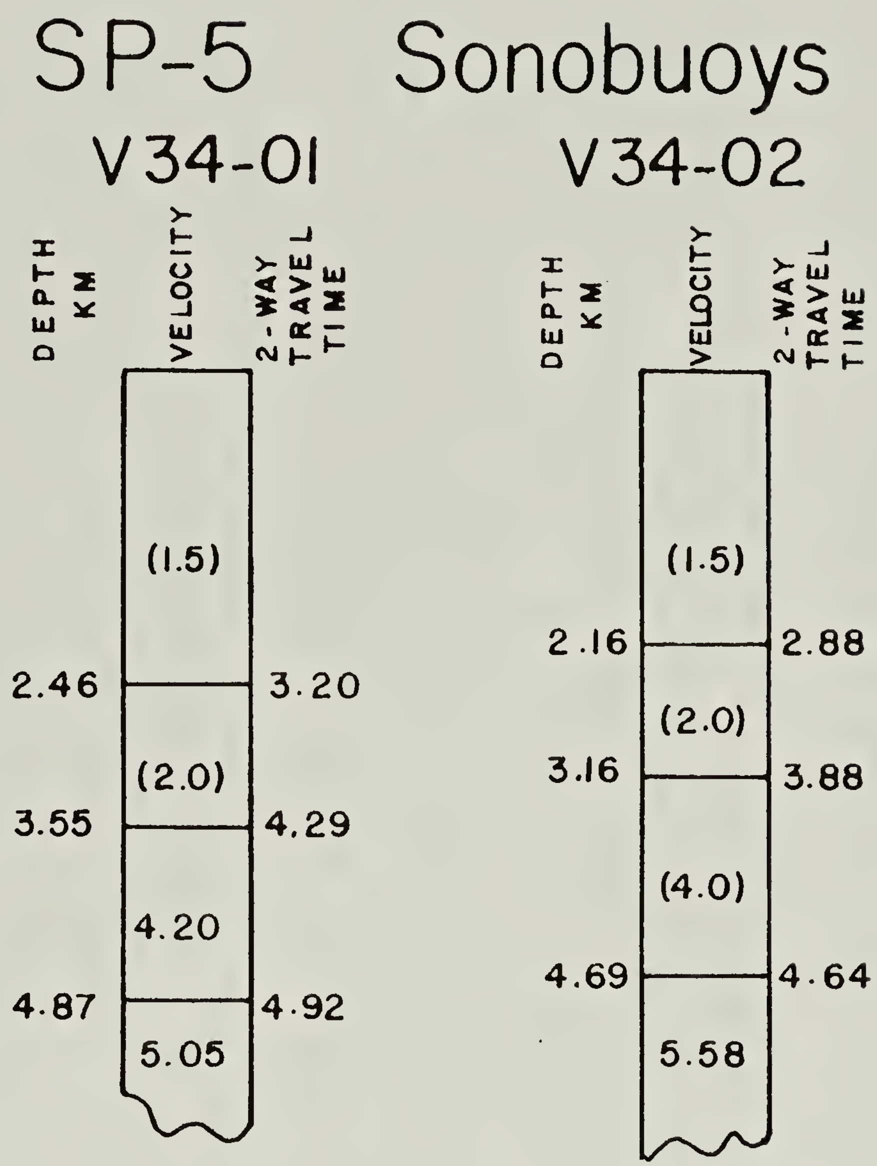


Figure 6

Reduction of the two sonobuoys shot on the West Mariana Ridge. Significant topographic slopes along the line of these profiles reduce their accuracy.

Site # 6A- The Parece-Vela Basin

Topography

The eastern part of the survey area, Figure 7, is located over the distal end of a sedimentary apron on the western flank of the West Mariana Ridge. The basement topography is buried below sediments so that the seafloor topography, Figure 8, is subdued and reflects both long wavelength topographic variations greater than 20 km and some smaller scale relief associated with gentle folding or faulting of the sediments. The seafloor deepens gradually toward the west, reaching a regional maximum of about 4900 m at about 140°20'W. At this point, the oceanic basement begins to emerge and at 140°E the sediment becomes extremely thin and mainly pelagic. Where the sedimentary cover is thick many slopes trend northeast and southeast, forming a vague orthogonal pattern seen throughout this part of the Parece Vela Basin.

The basement relief west of 140°E consists of high and broad ridges and furrows as seen in the east-west profiles of Figure 2 and Profile 5 of Figure 9. At about 139°15'E and 18°N an extraordinary feature exists; a 3 km deep, diamond shaped depression, about 25 km on a side. This depression is devoid of sediment and a dredge haul has been taken from the northwestern slope. The walls of this depression also trend northeast and southeast, apparently controlled by the same general fault pattern influencing the grain of the topography across this basin. The depression is one of the deepst examples of a number of deep troughs running along a line extending north from the Yap Trench Arc. These features appear to be downfaulted graben blocks in the upper oceanic crust.

The orthogonal pattern of slopes in the Parece Vela, apparent at Sites 6A and B, may reflect a pervasive fault pettern. The trends are at an angle of about 45° to the inferred direction of spreading that formed the basin. This faulting may have postdated the formation of the lithosphere underlying the basin. The very recent folding of the West Mariana sedimentary apron, evidence of postspreading tectonic movements, may result from continuing east-west tensional stress acting on the relatively rigid lithosphere now underlying the Parece Vela Basin.

Sediments

The acoustical characteristics of the sedimentary cover in the area of this site have been described by Karig (DSDP Leg 6 Scan IV report) at Site 53. Our 3.5 kHz records show a thin veneer of sediments 15 m thick covering the entire region. This layer is rather uniform in thickness except where the basement emerges, or, in depressions where the layer thickens slightly. There are two prominent subsurface reflectors in flat regions; one at about 7 m, probably corresponding to the base of a zeolitic clay unit cored at DSDP Site 53; the second at 15 m and probably corresponding to the silty radiolarian ooze base, Unit B of Fisher and Heezen (DSDP Leg 6 Report). These units represent a pelagic drape over the whole region. If properly correlated with 3.5 KC reflecting horizons, they are

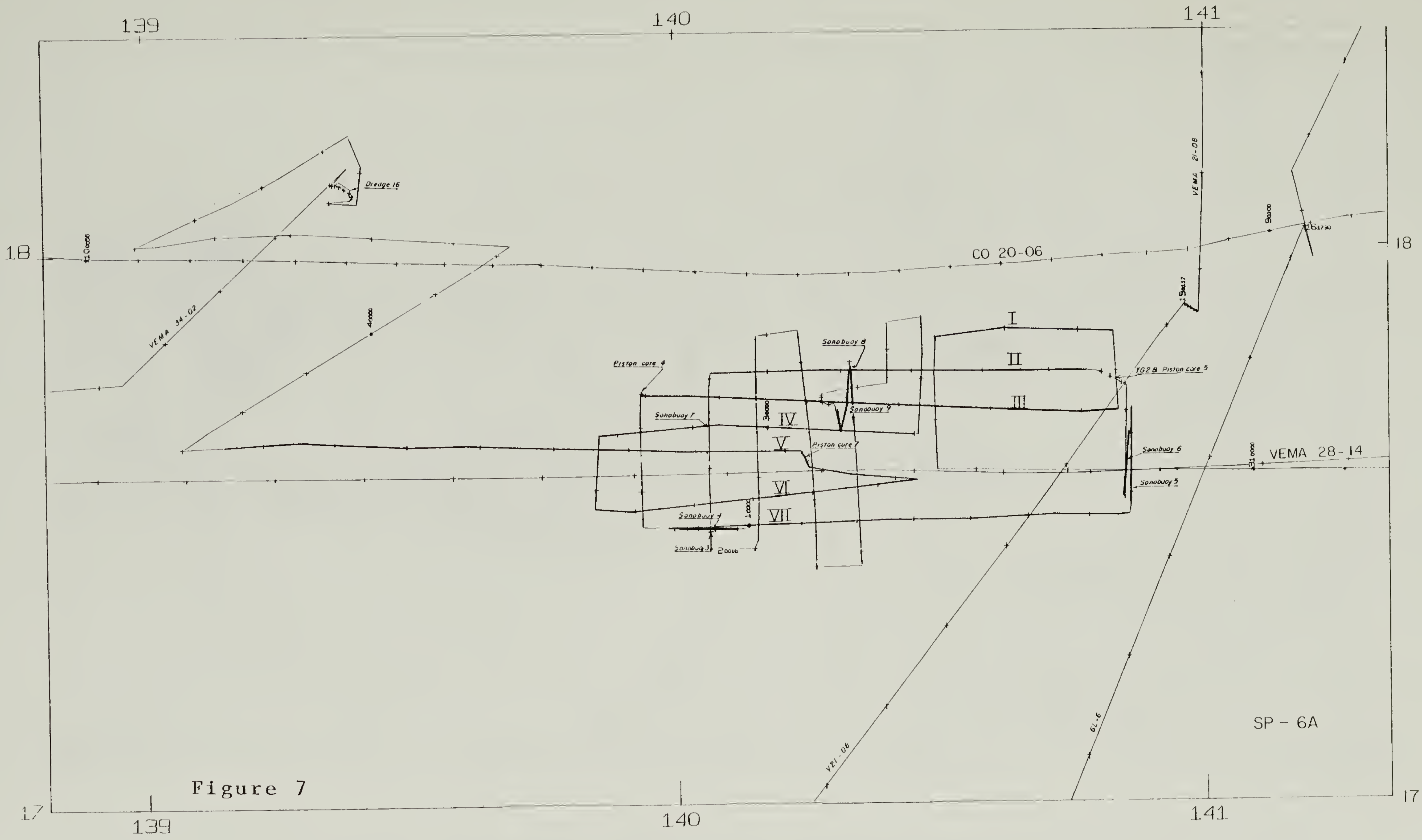


Figure 7

Track lines at Site #6A - TG represents heat-flow station.

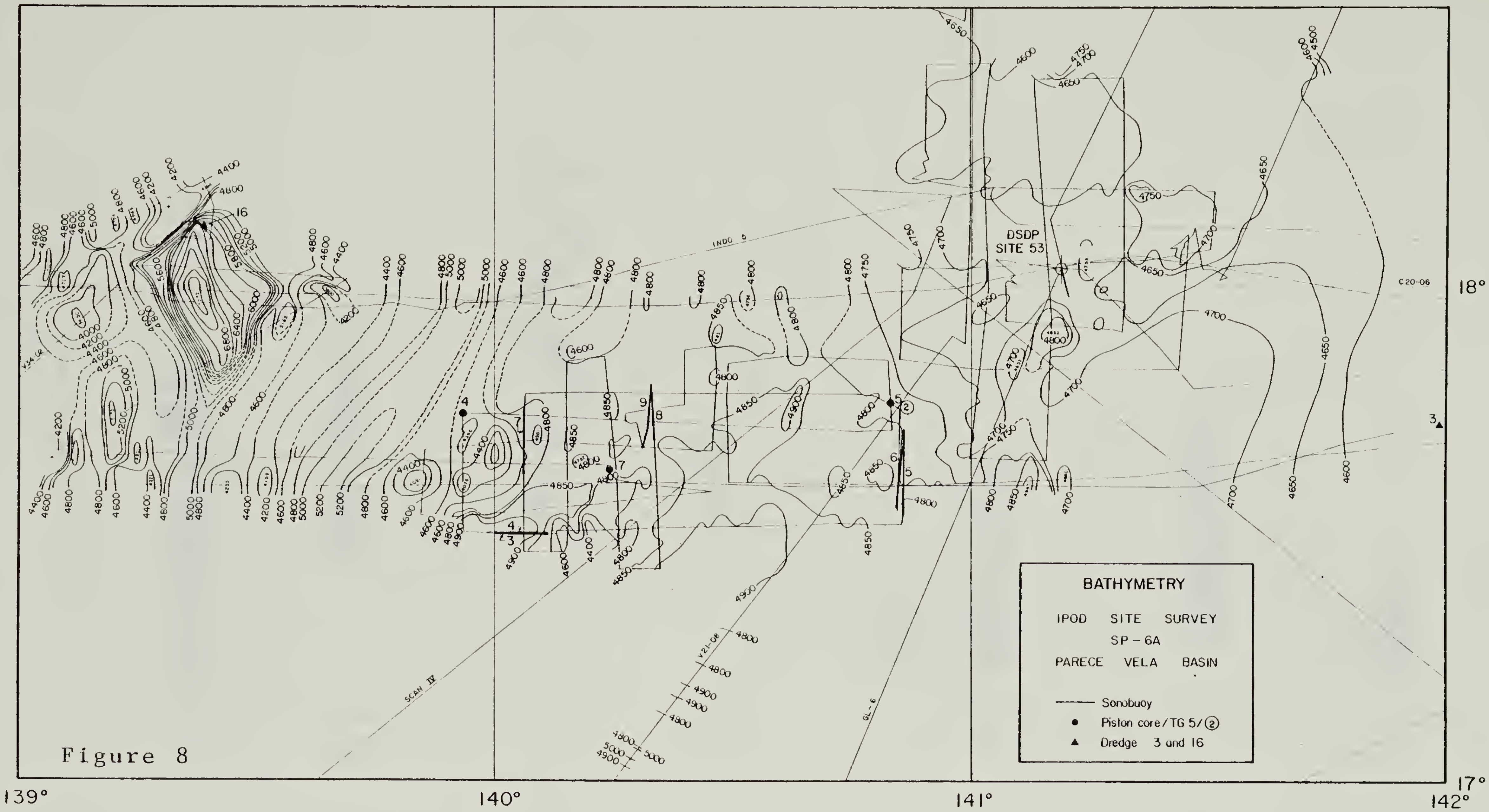


Figure 8

Bathymetry in the vicinity of Site #6A. West of 140°E the track line spacing is not dense enough to define the topography accurately.

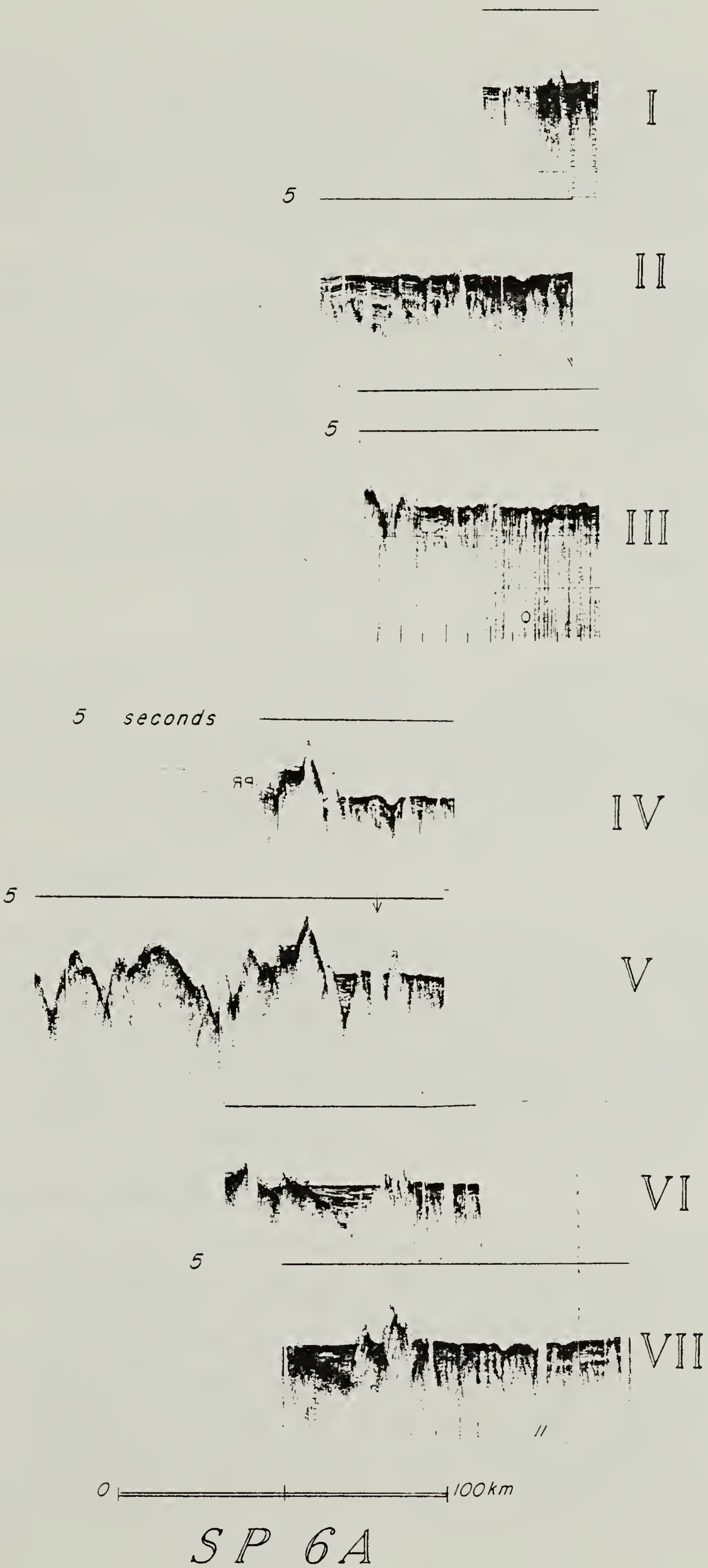


Figure 9

Selected seismic reflection profiles along east-west lines. Notice that on Profiles II,IV and VII the rounded depressions that are north-south trending furrows. These are taken as evidence for recent tectonics in the area.

thinner in the 6A area as compared with the Site 53 units. This suggests some contribution to this cover by laterally transported sediments from the east; probably windblown ashes and clays. The thickening of these layers in depressions also suggests this. The distribution of this sedimentary veneer indicates that its deposition postdates any tectonic movement that formed the trough-like depressions discussed earlier.

The reflector at 15 m is opaque; but, in places, reflectors may be seen deeper and these show intense stratification. The single channel seismic records show a thick zone (approximately 150 m) of closely spaced reflectors, the strongest of which can be traced throughout the area. These sequences of acoustic reflectors probably correspond to Unit C, defined at Site 53, which is comprized almost entirely of volcanic ash. Sediments at greater depth appear more transparent acoustically.

The basement topography, Figure 10, can rarely be discerned through the acoustically stratified sediments. The close approach of a peak to the seafloor is usually noted by the lack of stratification, Figure

Magnetics

Magnetic anomalies in the survey are of low amplitude. Maximum variations are on the order of 150 gammas, Figure 11. Nonetheless, the closely spaced tracks show clear north-south lineations. Some preliminary attempts to identify these anomalies indicate that they are near Anomaly 6, giving this part of the floor an age of about 20 m.y., in accord with the basement age of Late Oligocene to Lower Miocene found at Site 53.

Dredge at IPOD Trough

We have named the dramatic depression, of 7200 m maximum depth, the IPOD Trough. It is one of a number of such troughs and holes trending north from the near end of the Yap Trench. These lines of depressions are obviously tectonically related and collectively known as the Yap Trend. We dredged the base of the slope in the northern end of the IPOD Trough and scraped a suite of solid, fresh looking, blocks of basalt. The basalt is dense and aphanitic, and often has chilled rinds and clear alteration zones. There are thin manganese encrustations on the rocks.

Seismic Refraction Studies

Eight successful sonobuoys were made in the vicinity of this site, seven on the VEMA cruise 34, and one on the CONRAD cruise 20, Figure 12. Three of the profiles were reversed pairs, but they have not been treated as reversed refraction profiles in the reduction. Aside from the sedimentary layer for which we assumed a velocity of 2.0 km/sec, two deeper layers are discerned as refractors in the upper crust at many of the profiles. The shallower of these two layers has a mean velocity of 5.4 km/sec and probably corresponds to Layer 2 of the oceanic basement. At two locations, V 34-06 and V 34-08, layers with velocities of 6.7 and 6.45 km/sec, probably representing Layer 3, lie at a depth of about 6.9 km,

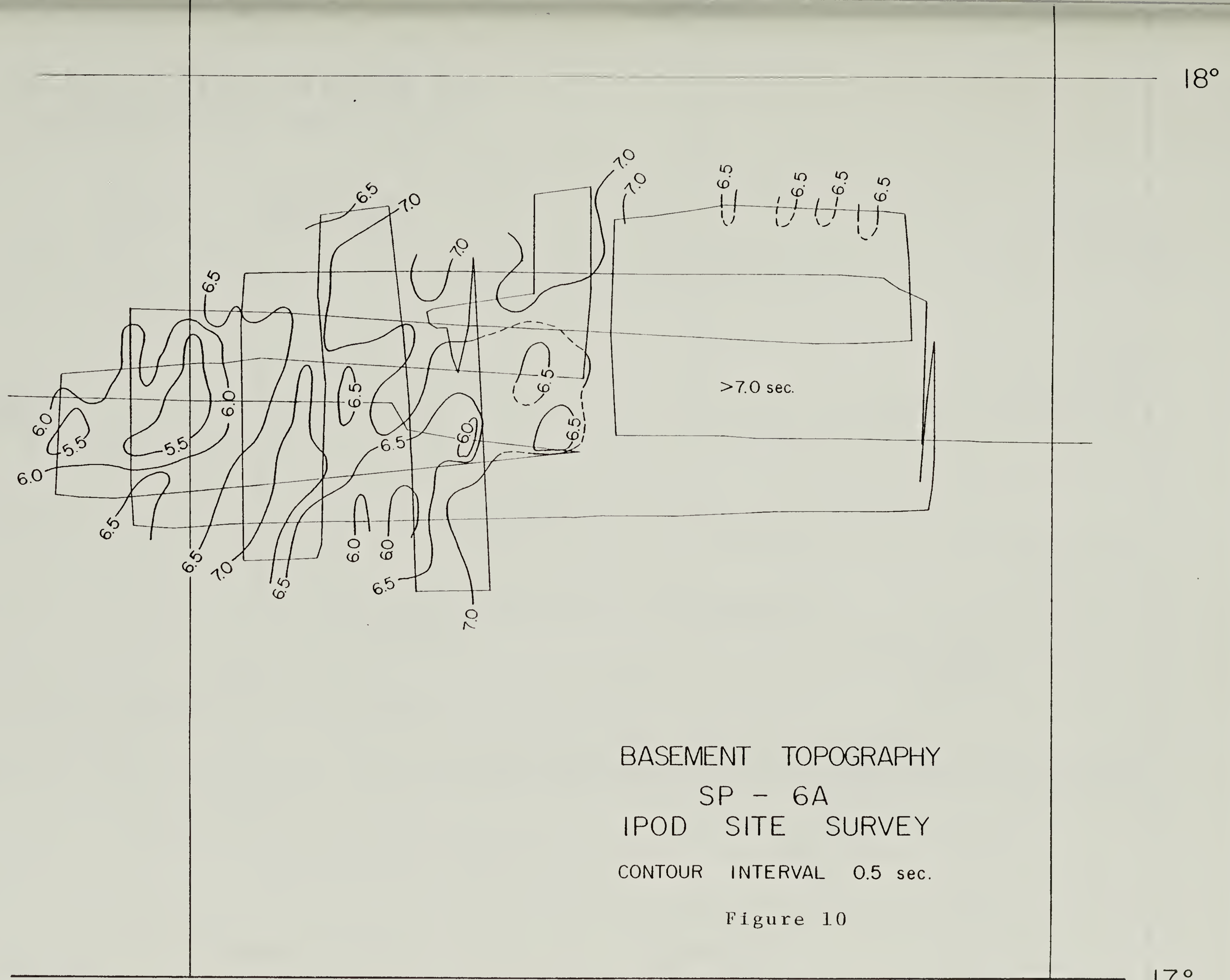


Figure 10

The basement topography in seconds of two-way travel time in the survey area where the basement is detected. There is a suggestion of a northwest trend to the main topographic blocks.

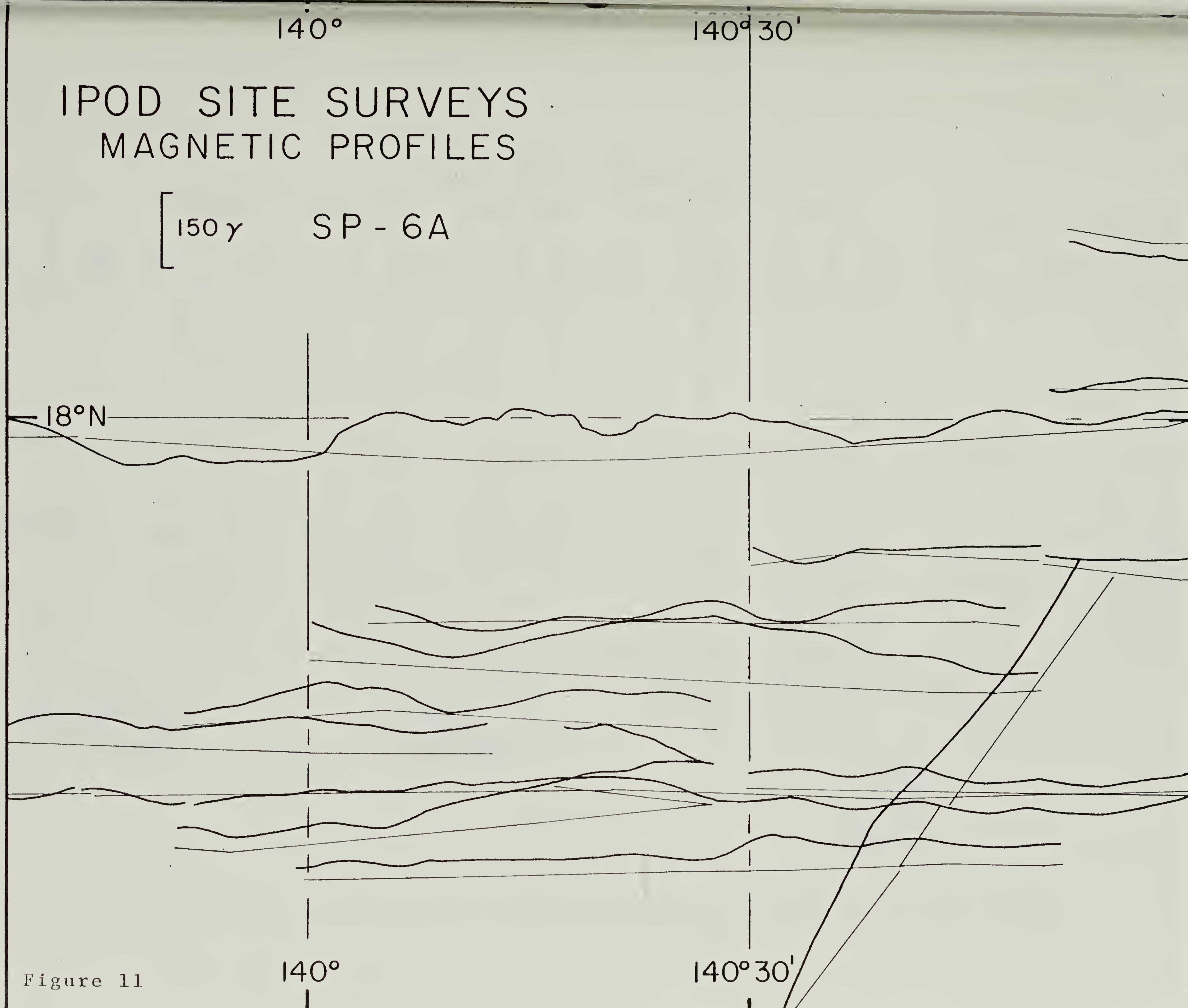


Figure 11

Magnetic anomalies along east-west tracks. The anomalies are of a very low level. Nonetheless, peaks and troughs can be traced from profile to profile quite well, suggesting a north-south lineation pattern.

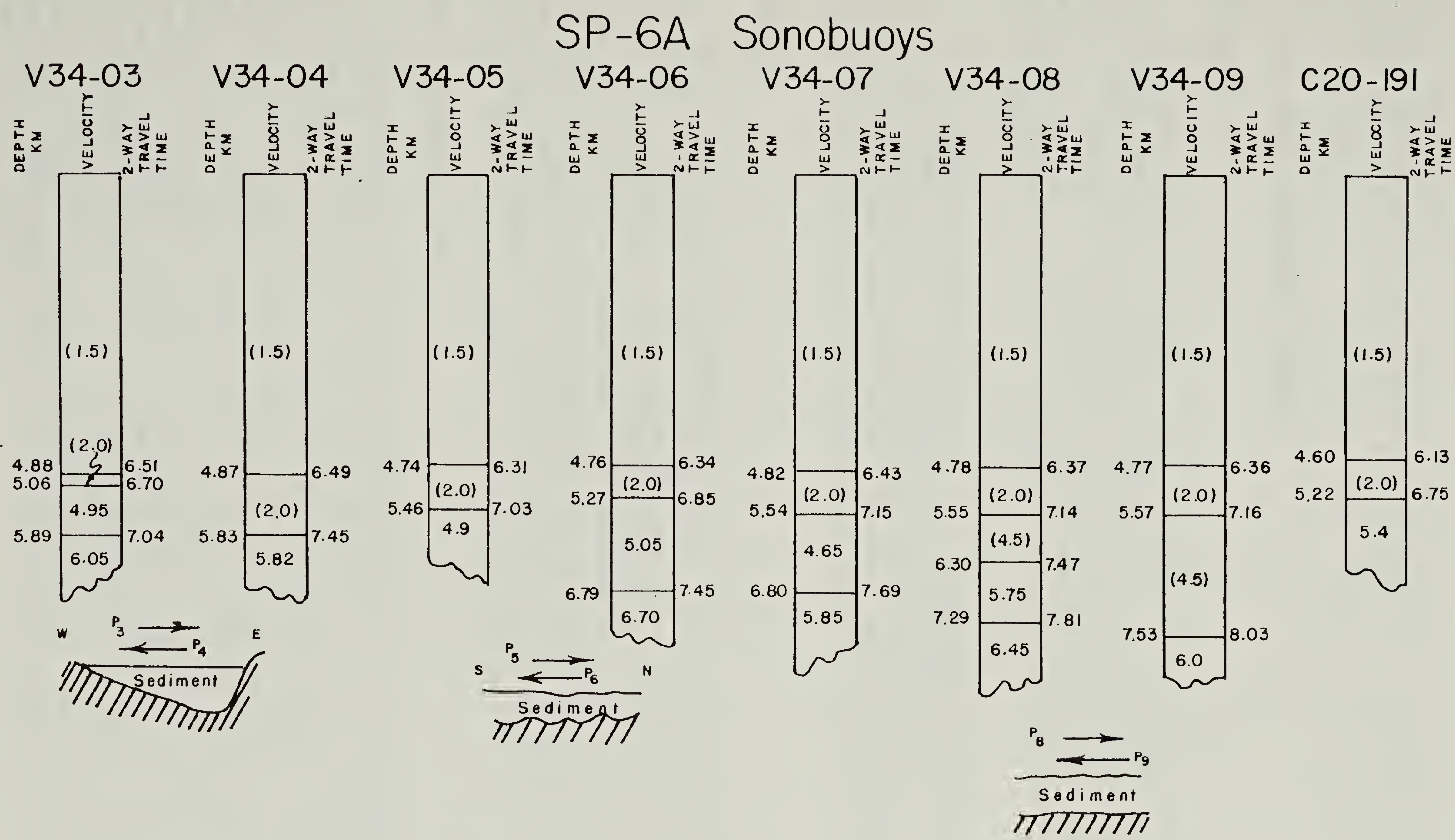


Figure 12

Solutions to sonobuoy refraction profiles made in the site survey area of #6A.

or about 2 km subbottom. An earlier two-ship refraction profile about 50 km east of the site (Murauchi et al., 1968, p. 24) interpreted this structure as 1.5 km of Layer 2 with a velocity of 5.0 km/sec and a Layer 3 of 6.8 km/sec velocity. The top of Layer 3 lies at about 7.5 km.

Site #6B - South Philippine Transect

Topography

This site, Figure 13, is just east of the Parece vela Ridge. The topography is extremely rough (e.g., profiles of Figure 2). The bathymetry in its present state of definition (Figure 14) does not clearly reveal patterns or trends. Depths range from 3900 m on one broad peak to 5800 m in five separate depressions. The deeper depths predominate but broad rise shoaling to depths of 4500 m are common. The average relief in the area is about 1300 m.

At a scale of about 35 km, the topography is shaped by elevated and depressed blocks. In places, the boundaries between these blocks form steep scarps in a roughly orthogonal trend. The best developed of these scarps trend about 040 or 130 (Figures 14 and 15). The blocky nature of the terrain is also well illustrated in profiles I, II and III of Figure 15.

Sediments

The thickness of the sediments in the survey region is generally thin; in only two places does it exceed 350 m. More typically, the cover is 100 m, see Figure 16. The thicker sediments are confined to the broad depressions in the area. The deposits are mainly abyssal pelagics. However, the thicker accumulation in the depressions, which generally do not conform with the basement contours, and the sparsity or absence of sediments on basement highs indicate either preferential deposition or mass movement subsequent to deposition. Preferential deposition is thought to be the most likely mechanism for the uneven thickness.

Seismic Refraction Studies

Seven sonobuoy refraction profiles were run, but five of these were in topography so rough that they cannot be reduced to give reliable layer velocities or thicknesses. Two of the profiles in the deeper southwestern part of the area, sonobuoys 15 and 16, gave reliable results, Figure 17. Sonobuoy 15 indicates a relatively thin Layer 2, about 400 m, overlying a Layer 3 with a velocity of 6.8 km/sec. Profile 16, intended to be a reverse of Profile 15, yields a thicker Layer 2 (800 m) with a velocity of 5.3 km/sec and a Layer 3 velocity of 6.2 km/sec. These differing results may reflect a dipping interface in the northerly direction of the profiles. A two-ship refraction profile (Murauchi et al., 1968, p. 25) southeast of Site 6B yielded a similar structure with the exception that a low velocity oceanic basement of 3.1 km/sec was observed over a 4.8 km/sec Layer 2. The Layer 2 - Layer 3 interface lies at about 7 km. The refraction results in the Parece Vela Basin show it to be underlain by a rather typical oceanic crustal structure.

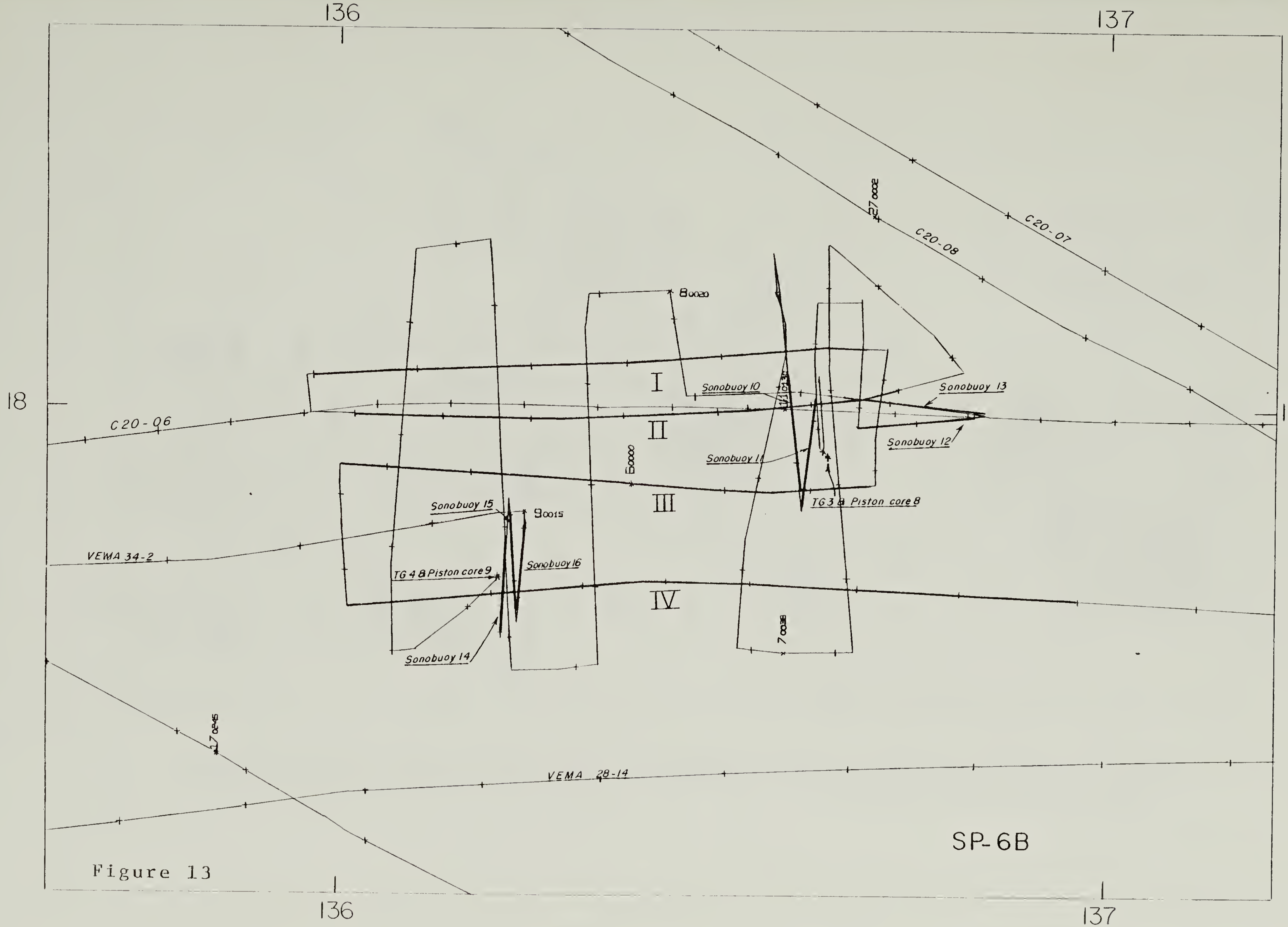


Figure 13

Tracks at Site #6B.

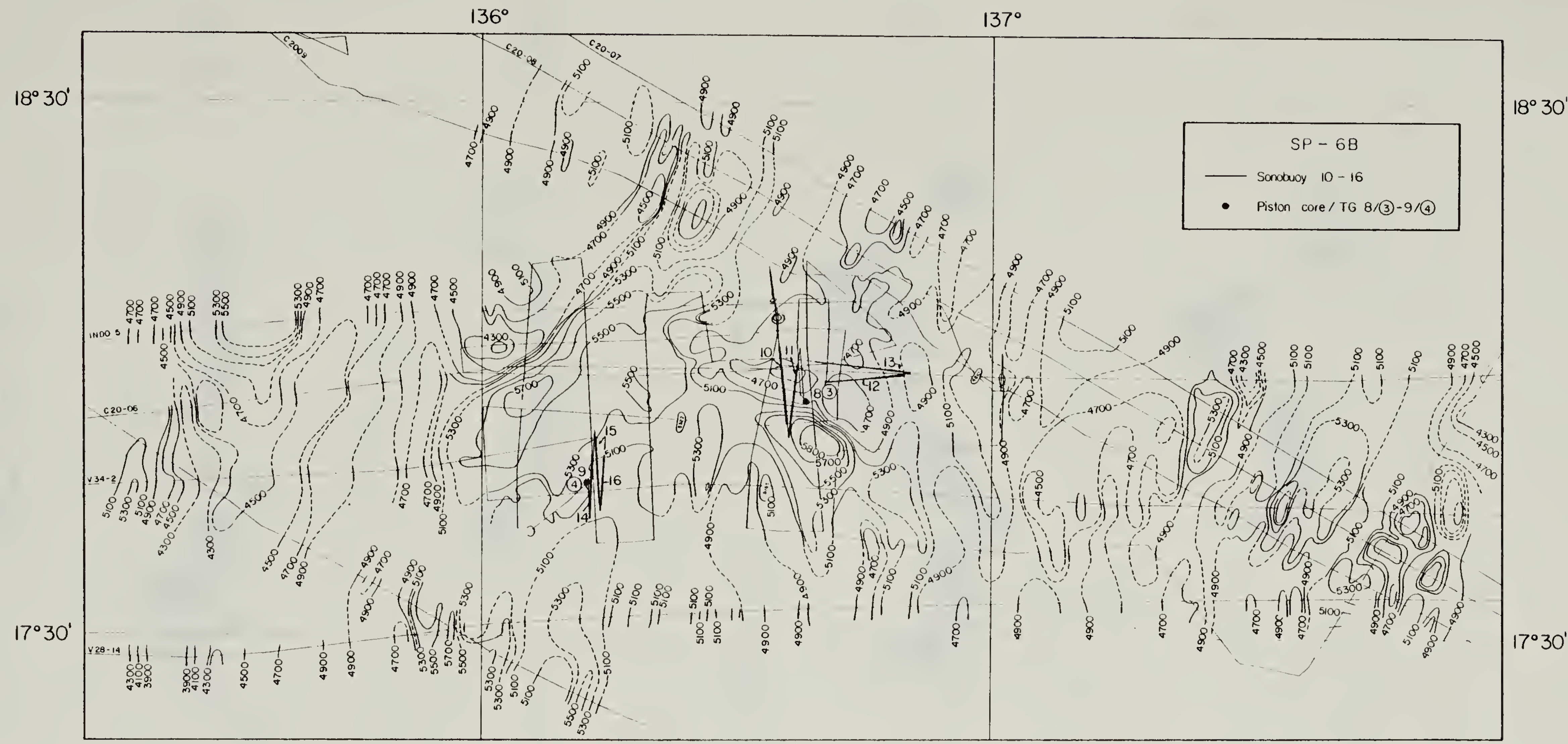


Figure 14

Bathymetry in the vicinity of Site #6B. The dashed contours reflect uncertainty because of insufficient coverage by the tracks. The symbol TG stands for a heat-flow station.

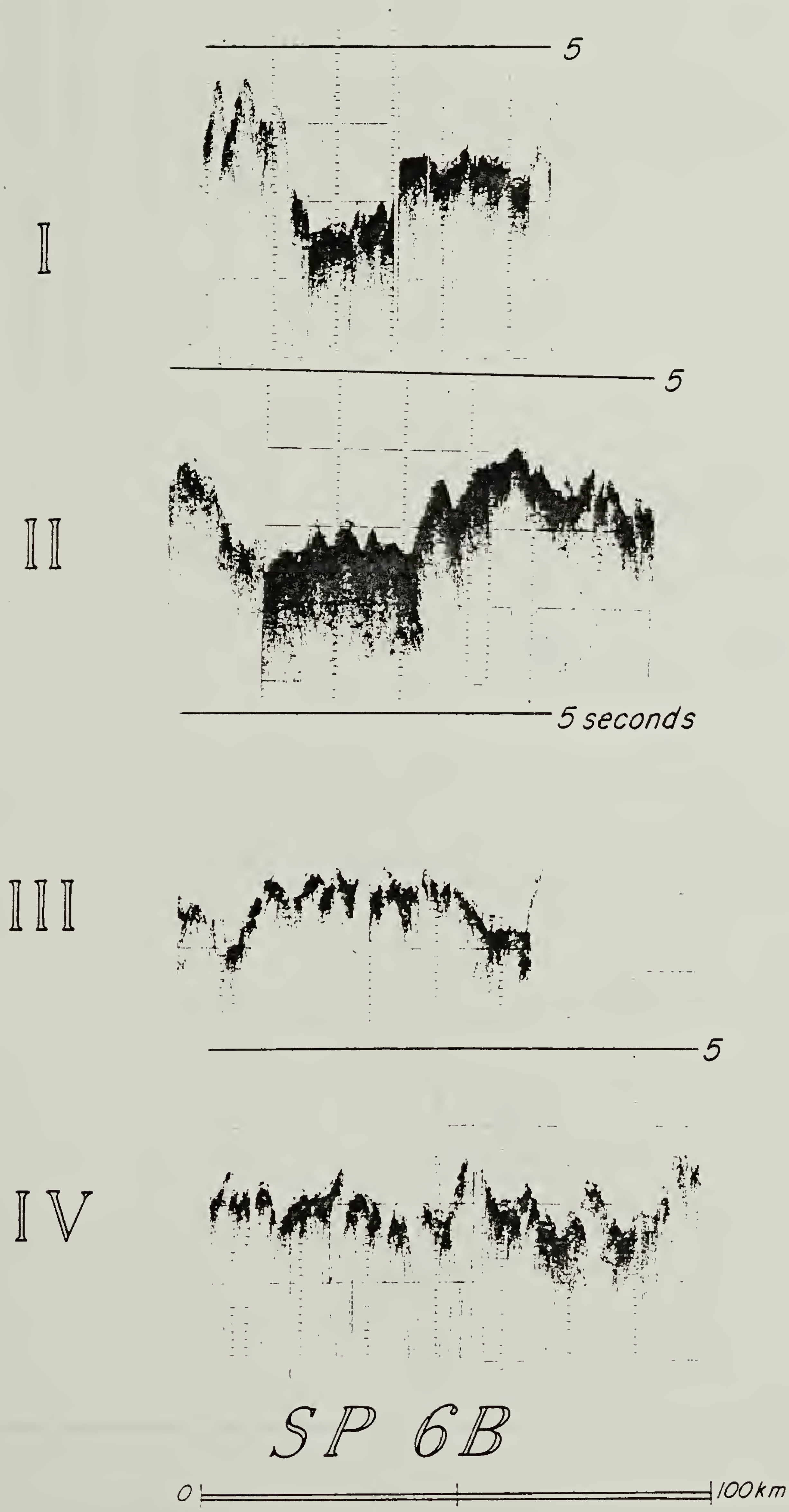


Figure 15 Four east-west seismic profiles across the #6B area.

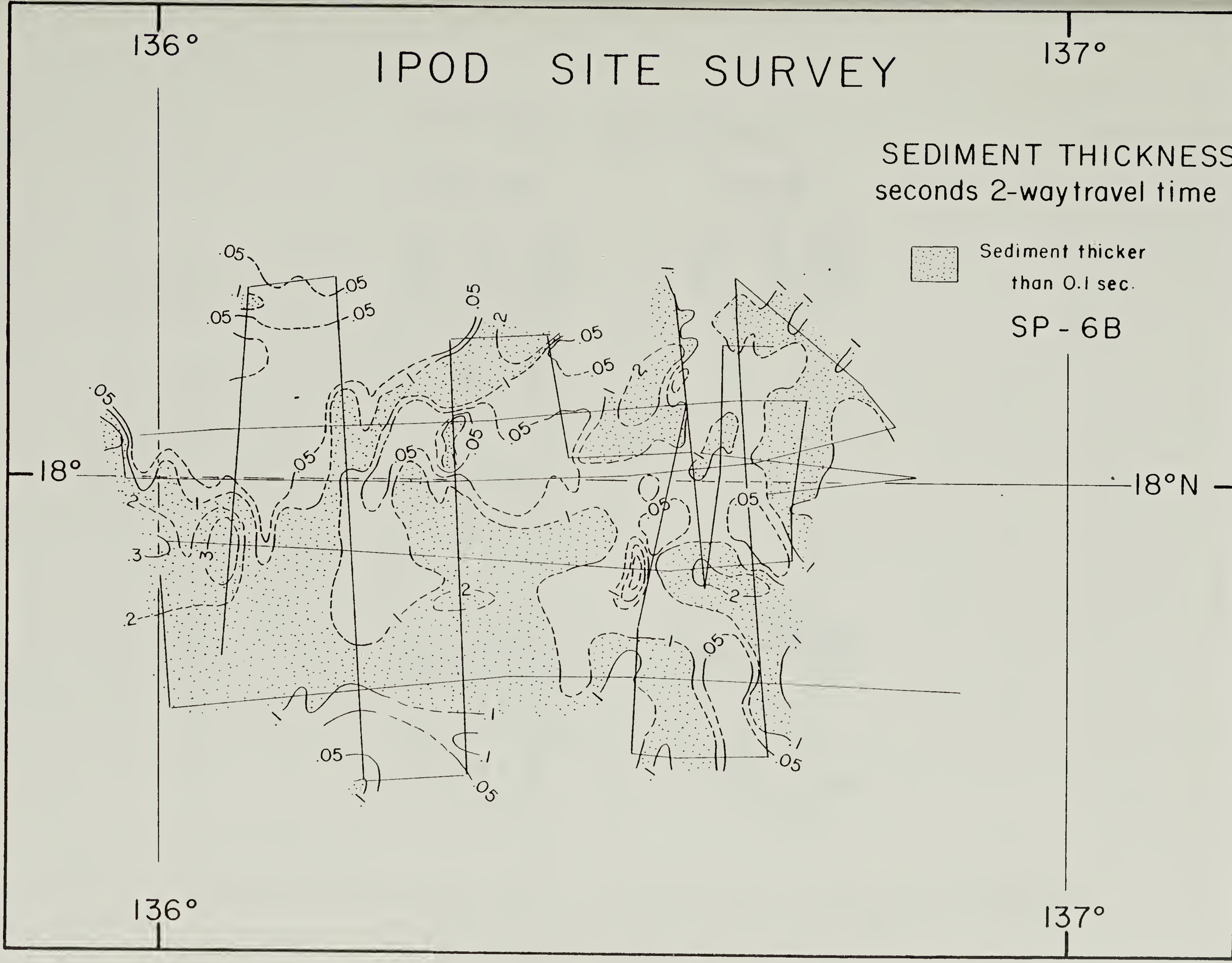


Figure 16

Isopach map of sediments at #6B

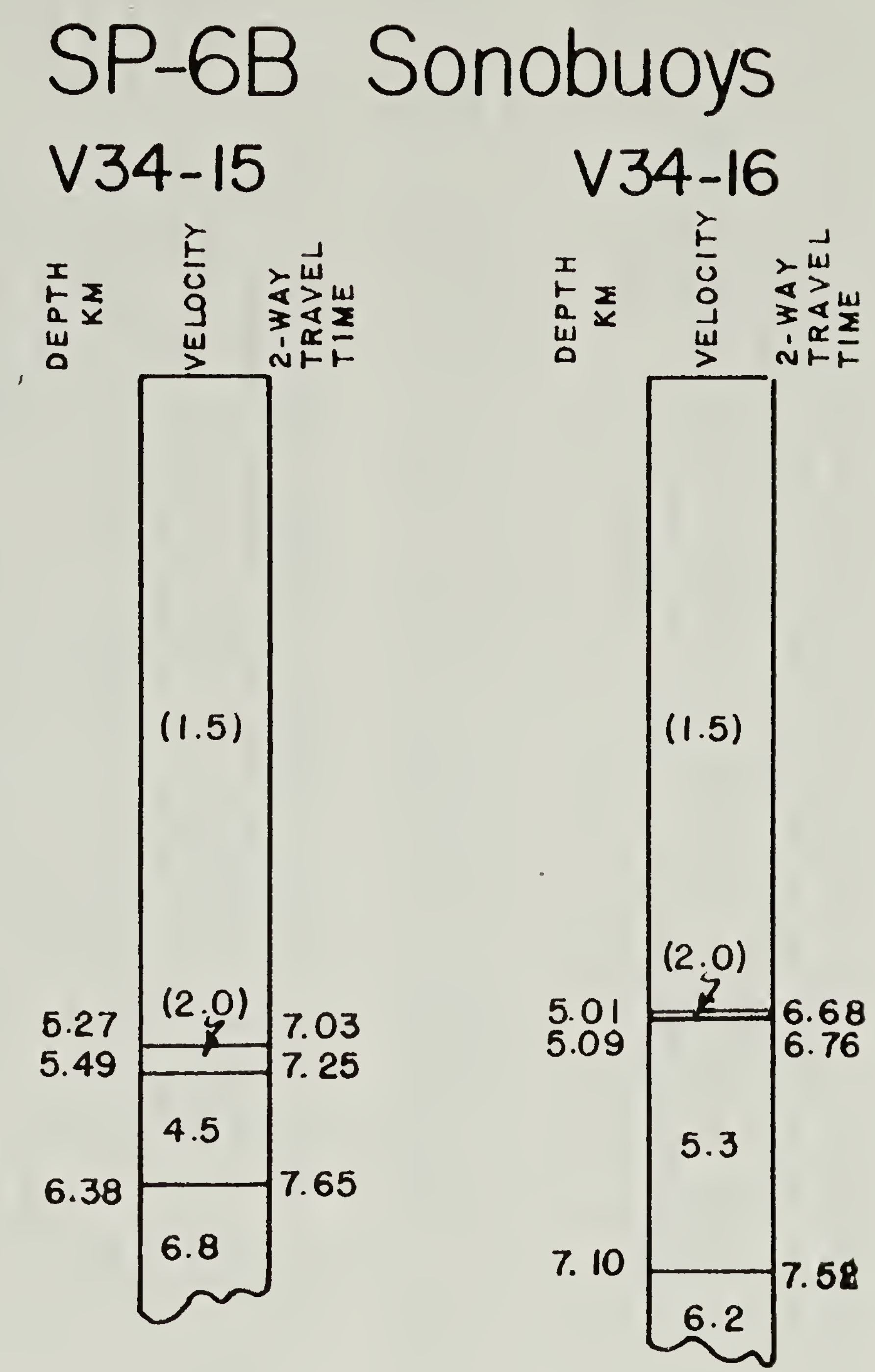


Figure 17

Solution to two sonobuoys shot in relatively smooth topography (See Figure 14). The results show that the crust here is oceanic.

Magnetics

Despite the low amplitude anomalies that characterize the entire Parece Vela Basin, a rather clear north-south lineation is defined by the east-west tracks, Figure 18. Preliminary identification of the anomaly sequence suggests that they span an age from 25 to 28 m.y., that is, Late Oligocene.

Until the IPOD survey program, no discernible pattern in the magnetic anomalies was observed. This was in part due to the wide spacing between track lines. The closely spaced east-west lines run during the IPOD survey work and recent tracks by the CONRAD have revealed both a symmetry and north-south lineation to the pattern. The accompanying Figure 19 shows magnetic profiles along main east-west tracks.

The north-south lineations are most clearly seen in the east-west tracks in the detailed survey areas 6A and B, although a major fracture zone may run through 6B at about 17°55;N. A symmetry in the profiles is discernible around the Yap Trend. This chain of troughs appears to be an extinct ridge axis which was the locus of lithospheric formation in the Parece Vela Basin. Its present position is roughly in the center of the basin.

We have tentatively identified the anomaly sequence as part of the relatively recent Tertiary reversal chronology, anomalies 5C - 9., which would imply that this basin formed between the Late Oligocene and the Middle Miocene.

In view of the vague magnetic anomaly pattern developed in the region, fresh basement samples from the vicinity of sites 6A and 6B for dating purposes are essential. Both sites have relatively well developed anomaly patterns that can be used as a guide to site the location. In area 6A, the nearly sinusoidal variations are thought to be part of the Anomaly 6, 6A and 6B sequence. Whereas, in area 6B, the low amplitude sequence of three cycles is thought to be Anomalies 7, 7A and 8. Magnetic evidence suggests that oceanic crust closest to the eastern margin of the Parece Vela Ridge was formed between Anomaly 9 and Anomaly 10 time. This would indicate that the formation of the Parece Vela Basin began before the opening of the Shikoku Basin.

Site # 7 - The Parece Vela Ridge

Our survey of the Parece Vela Ridge (also called the Palau-Kyushu Ridge) was moved south of the Transect Line at 18°N because previous tracks had suggested that the ridge was not continuous in the vicinity of the transect. Instead, we surveyed an area centered around 16°12'N (Figure 20), where an earlier track, CONRAD 11-07, showed the ridge to be broader and higher than tracks at 18°N.

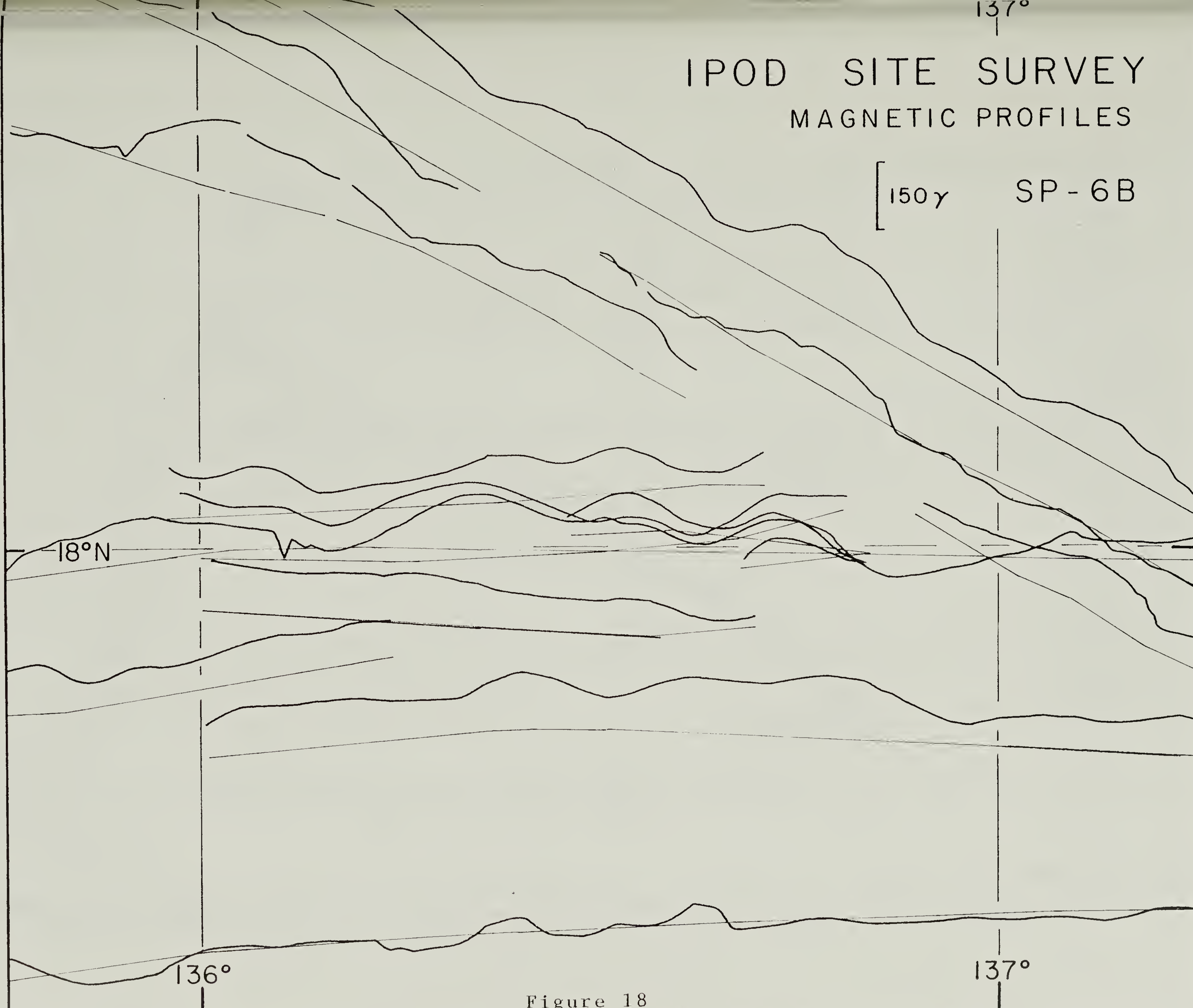


Figure 18

Magnetic anomalies along tracks in the vicinity of #6B. Some north-south lineations are evident despite the very low amplitude of the anomalies.

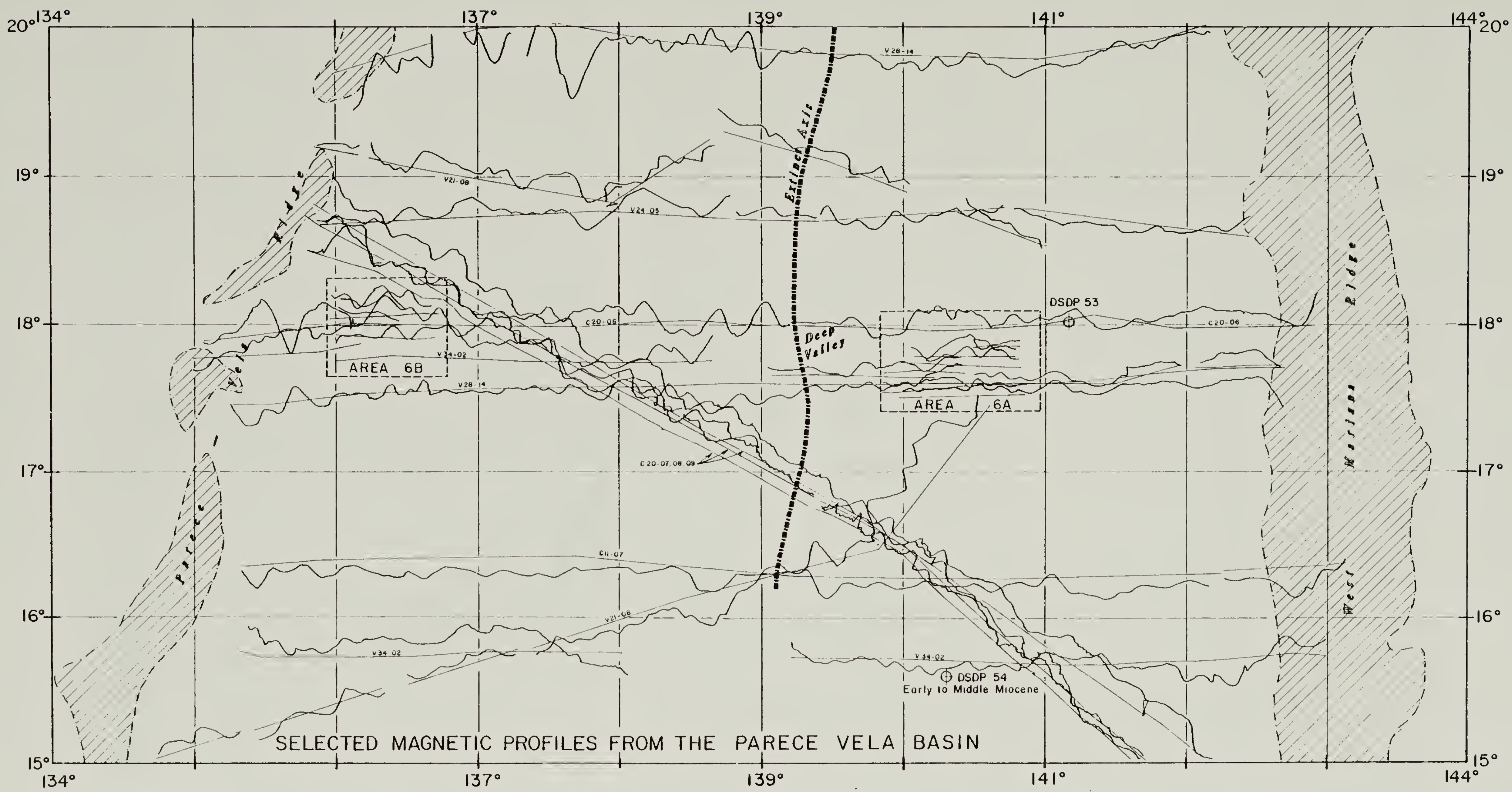


Figure 19

Summary map of magnetic anomalies along east-west tracks in the Parece-Vela Basin. The shaded areas represent the Parece-Vela Ridge on the left and the West Mariana Ridge on the right. The dark axis, running along about 139°20'E is thought to be the extinct axis of spreading in the basin

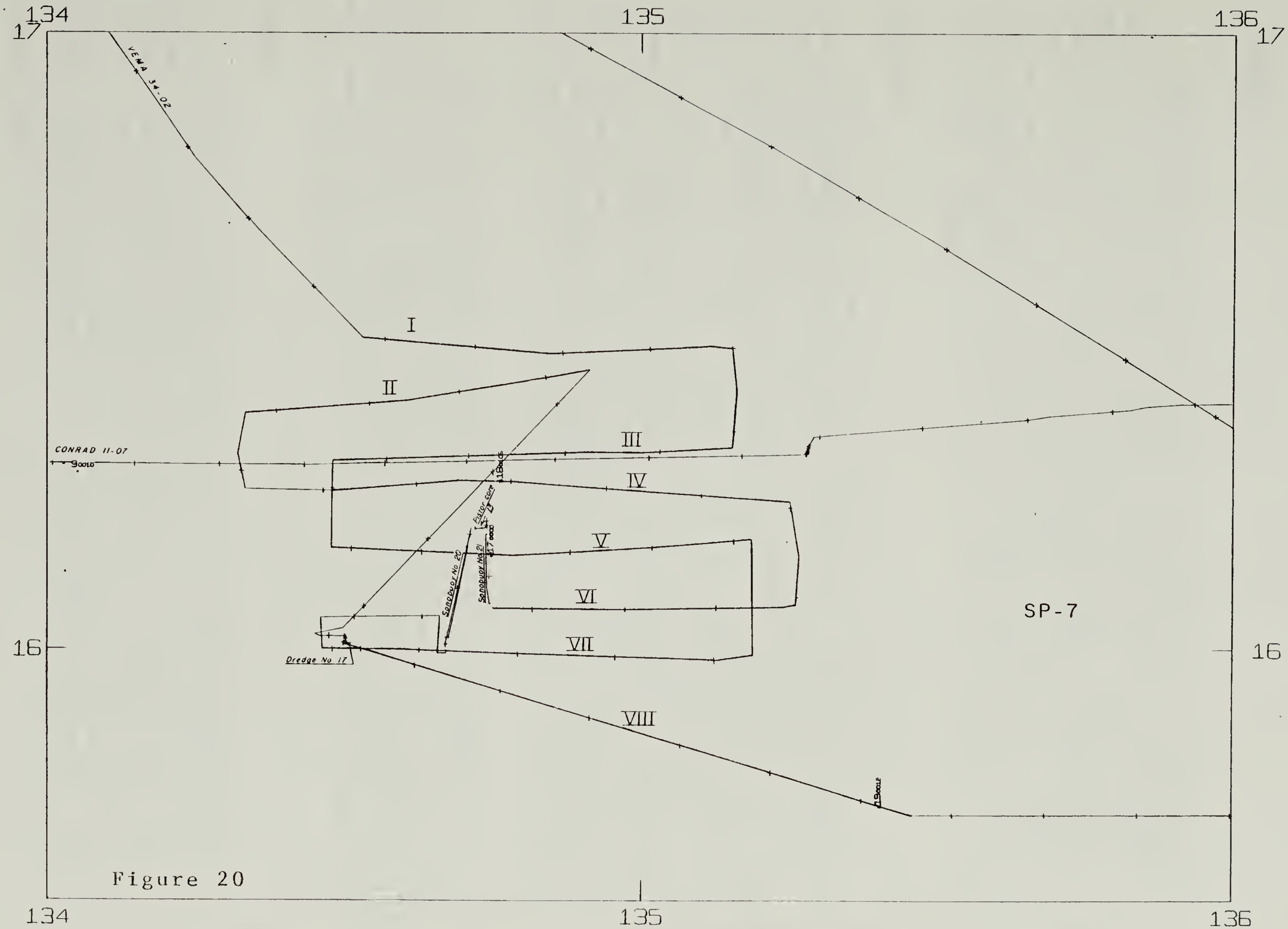


Figure 20

Track lines at Site #7 on the Parece-Vela Ridge. This site is nearly two degrees south of the transect line because, based on earlier profiles, it was not considered to be well developed at 18°N (see Figure 19 for example).

Bathymetry

Detailed surveying of the Parece Vela Ridge shows the morphology to be complex (Figure 21). For example, between 16° and 16°21'N there appears to be a relatively well developed ridge crest on the eastern part of the ridge with a steep eastern facing scarp. However, this local ridge does not continue to the north and south. On the western flank of the ridge, steep sided mounds suggest volcanic piles similar to those seen on the western flank of the West Mariana Ridge. Except for the greater depth of the Parece Vela Ridge, a minimum depth of 2900 m versus 1600 m for the West Mariana Ridge, the morphology in plan is strikingly similar.

Sediments

On the ridge the sediment is concentrated in pockets formed by protruding basement ridges and peaks (Figure 22). There is a veneer of acoustically transparent sediments, 0.2 to 0.3 seconds thick covering these pockets and areas of relatively flat terrain, Profile 7 in Figure 23. These probably represent pelagic carbonates since they become thinner near the base of the ridge, Profiles I and II. Beneath the transparent deposits there is a layer of highly opaque and stratified sediments. Only occasionally can reflectors be detected below these reflectors. The presence of basement in close proximity to the seafloor is evidenced by the disappearance of this thick opaque layer. These sediments are probably volcanoclastics and ashes, perhaps deposited when the ridge was active and had islands projecting above the sea level. Unfortunately, these deposits make it extremely difficult to trace the basement over the ridge.

The IPOD Site Survey's multichannel line over the ridge indicated a thick apron of sediments on the western flank of the ridge. Except for pockets, the eastern flank has a thin sedimentary cover. This indicates that this apron was formed at a time prior to the opening of the Parece Vela Basin. At that time, the Parece Vela Ridge may have been much more massive, including components of the cores of the West Mariana Ridge and even the Mariana Arc.

Dredges

A dredge, No. 17, was taken on the steep westward facing scarp in the southwestern corner of the survey area. A single large boulder was dredged consisting of agglomerated fragments of volcanic rocks. The fragments were rounded and most were covered by a manganese rind. The split pieces, orange to grapefruit in size, reveal a highly vesicular basalt. Considering the depth from which this sample was acquired, it probably represents fragments of flows from higher on the ridge. The high vesicularity suggests that it may have come from flows extruded in shallow water.

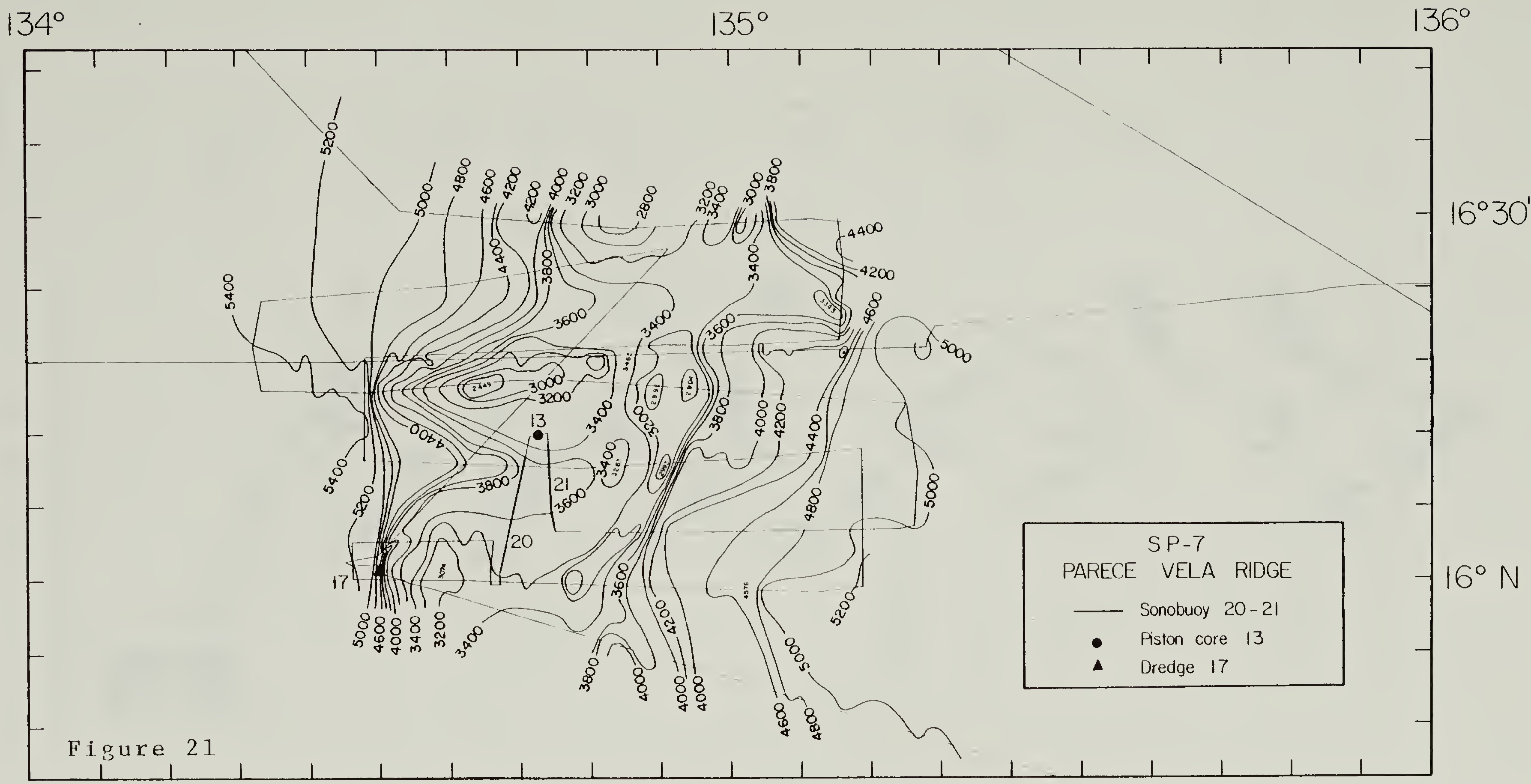


Figure 21

Bathymetry of the Parece-Vela Ridge at Site #7.

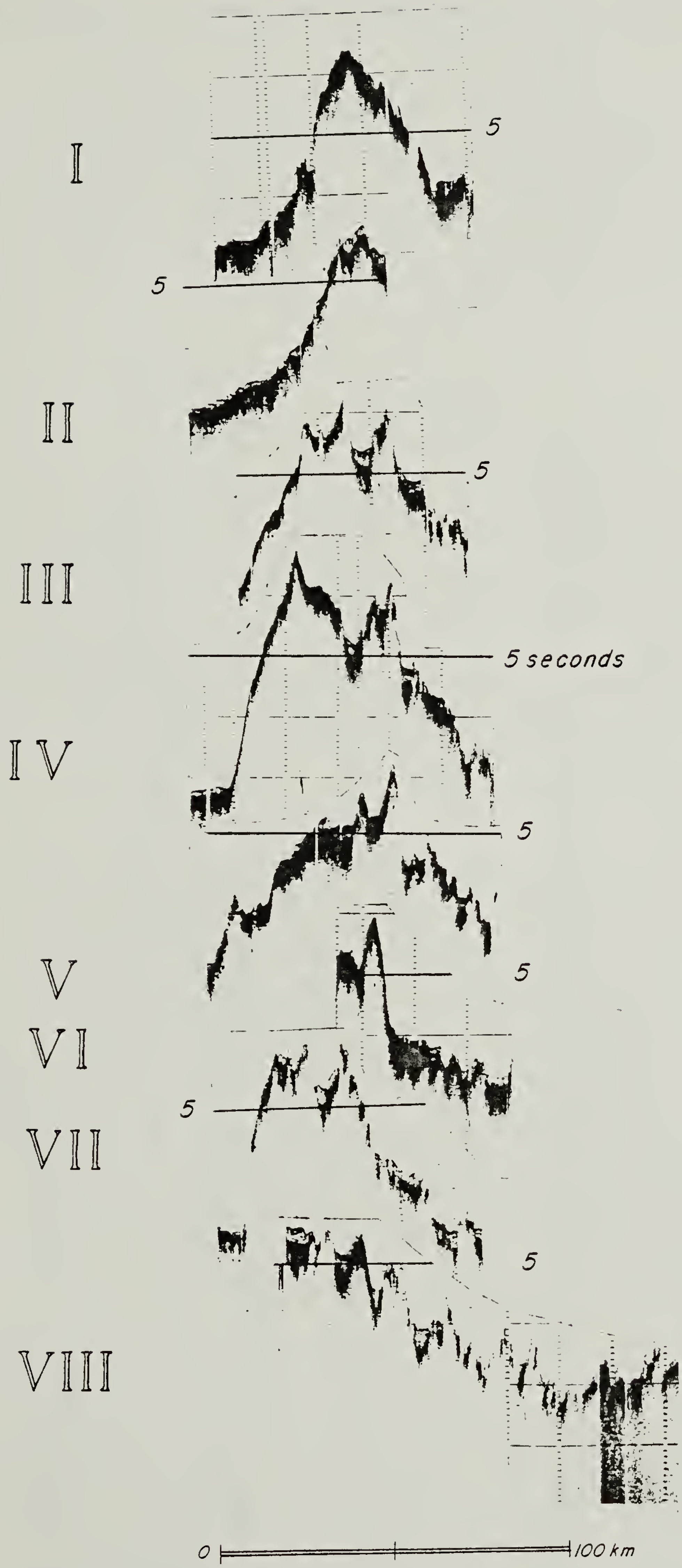


Figure 22

Seismic reflection profiles over the Parece-Vela Ridge.

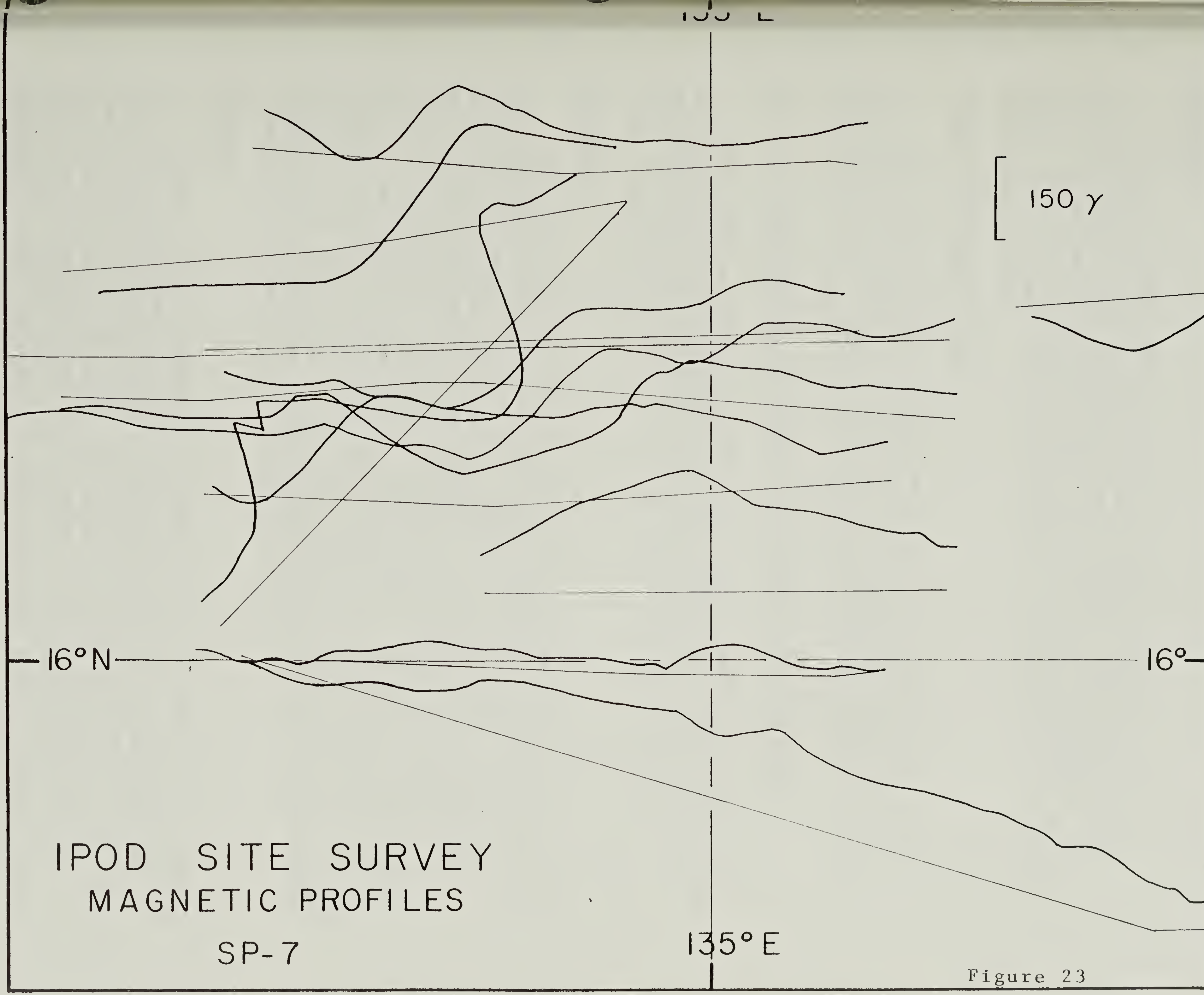


Figure 23

Magnetic anomaly profiles over the Parece-Vela Ridge.

Magnetics

Figure 23 shows magnetic anomalies along east-west tracks. Considering the basement relief of the ridge, the magnetic anomalies associated with this ridge are extremely subdued. This suggests that the volcanism associated with this ridge occurred at low magnetic latitudes. The profiles suggest some continuity of anomalies along the ridge axis. Further studies of the magnetic anomalies along this ridge could prove fruitful.

Seismic Refraction Studies

Only one reducible sonobuoy was made over the southern part of the survey area on the Parece-Vela or Palau-Kyushu Ridge. The profile was oriented approximately north and the topographic profile shows a dipping seafloor. A single refractor was detected at a depth of 3.4 km, 0.7 km below the seafloor with a velocity of about 4 km/sec.

Site # 8 - Near the Eastern Margin of the West Philippine Basin

This site anchors the western end of the transect and is near the eastern margin of the West Philippine Basin, Figure 25. A site not far from the recommended site was drilled during Leg 31, DSDP Site # 290. The objectives of the new hole were to drill as deeply as possible into the oceanic crust.

Bathymetry

Prior geophysical tracks in the area indicated that the major trends and lineations in the area ran 280 to 290; therefore, the main track line were oriented along 015 (Figure 25). Compared to the other sites, the bathymetry is subdued. The average depth is nearly 6000 m, as deep as most of the older basins of the Pacific. The relief is on the order of 200 meters (Figure 26). The basement topography, Figures 27 and 28 is formed by subparallel ridges about 200 to 400 meters high and about 8 km apart. The trend of these ridges is about 285°. There is a steep sided V-shaped valley in the southern part of the survey area, profiles A and E of Figure 28. The rims of this valley form the highest feature in the area. The mean depth to basement slopes gently downward toward the north. In the northern part of the area, sediments have filled the valley floors between ridges greatly attenuating the topographic relief.

Sediments

In general, the sedimentary blanket in the area does not lie conformably over the basement terrain, rather the depressions have been preferentially filled, indicating that a large proportion of the sediments have moved laterally into the area. The source of these sediments is from the Parece Vela Ridge to the east and the area lies at the distal end of the sedimentary apron over the western flank of the ridge. This is in accord with the stratigraphic section drilled at DSDP Site # 290, where 90 meters of Quaternary to Late Oligocene silt rich clays were found to lie over about

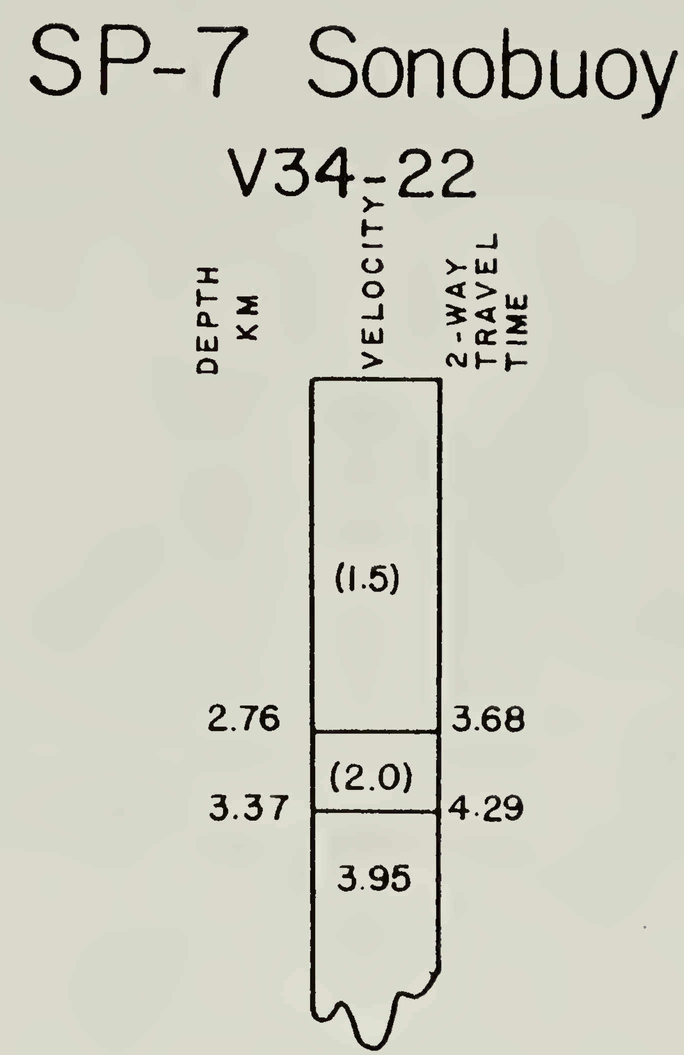
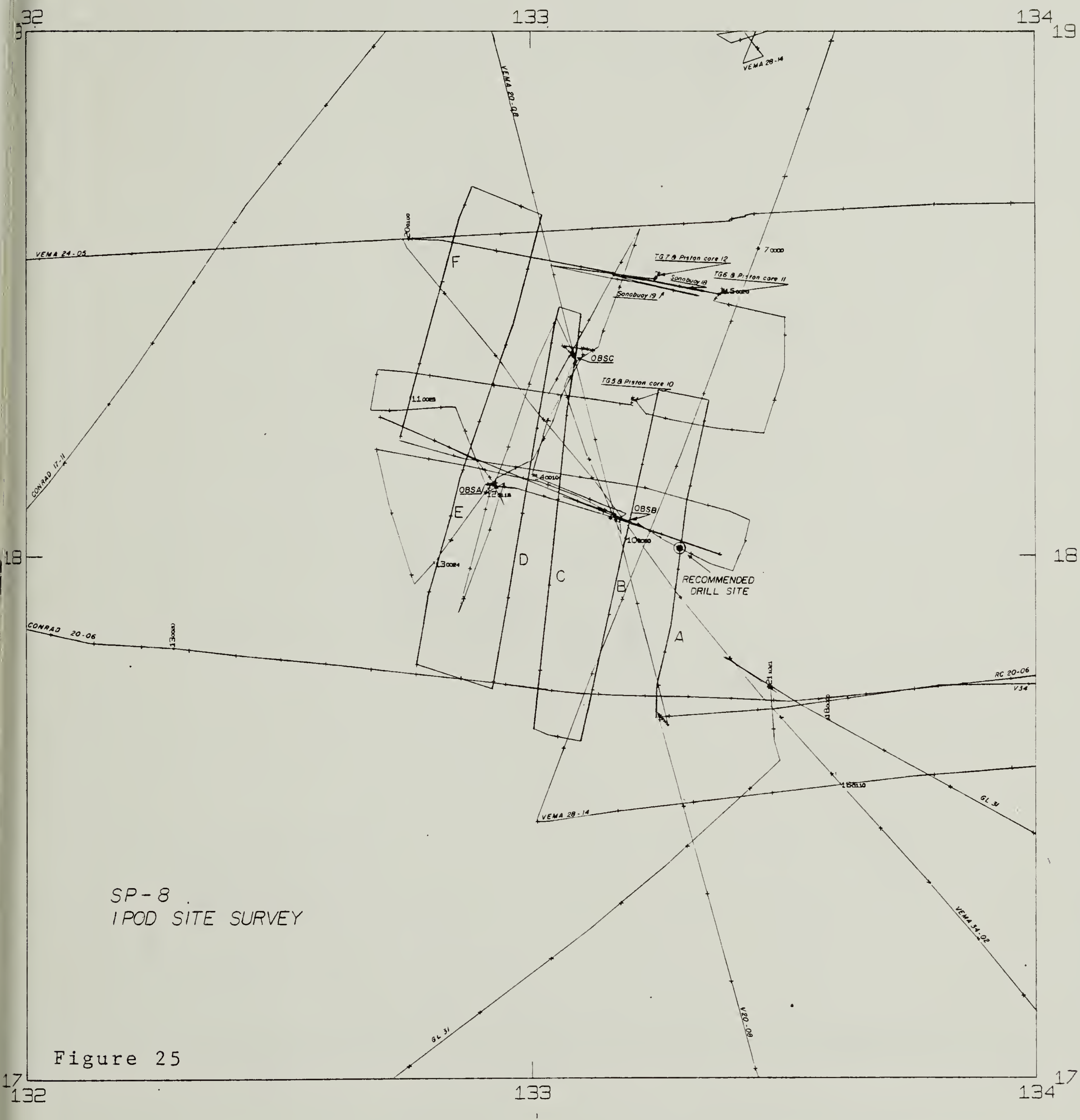
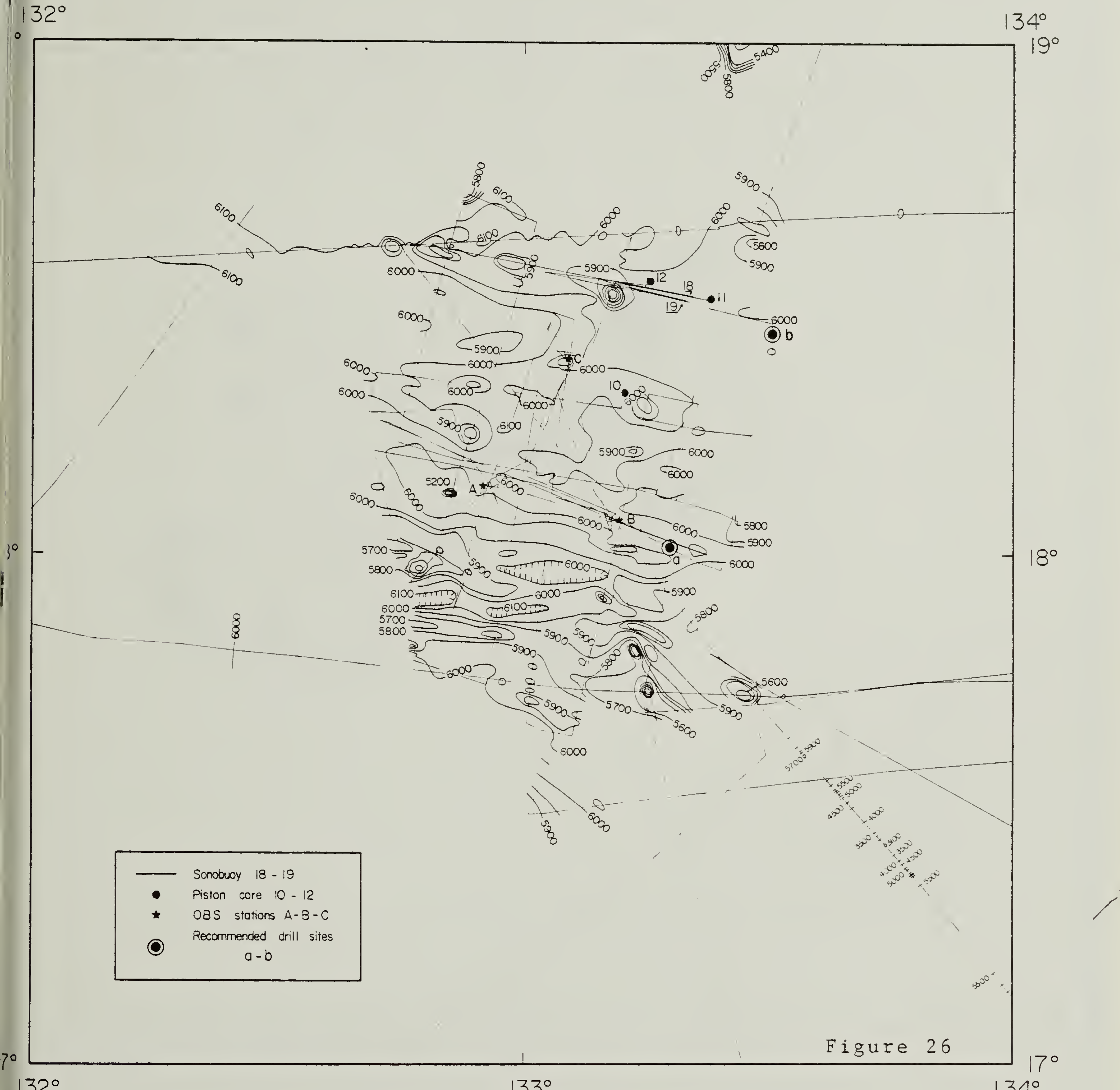


Figure 24

The solution to the one successful sonobuoy shot at #7. Only one refractor was recorded.



Track chart in the vicinity of #8. OBS, A, B and C are the locations of ocean bottom seismometer drops. Only the unit at A recorded useful data.



Bathymetric map of Site #8.

Figure 27

Basement morphology in tenths of second two-way travel time and sedimentary thickness.

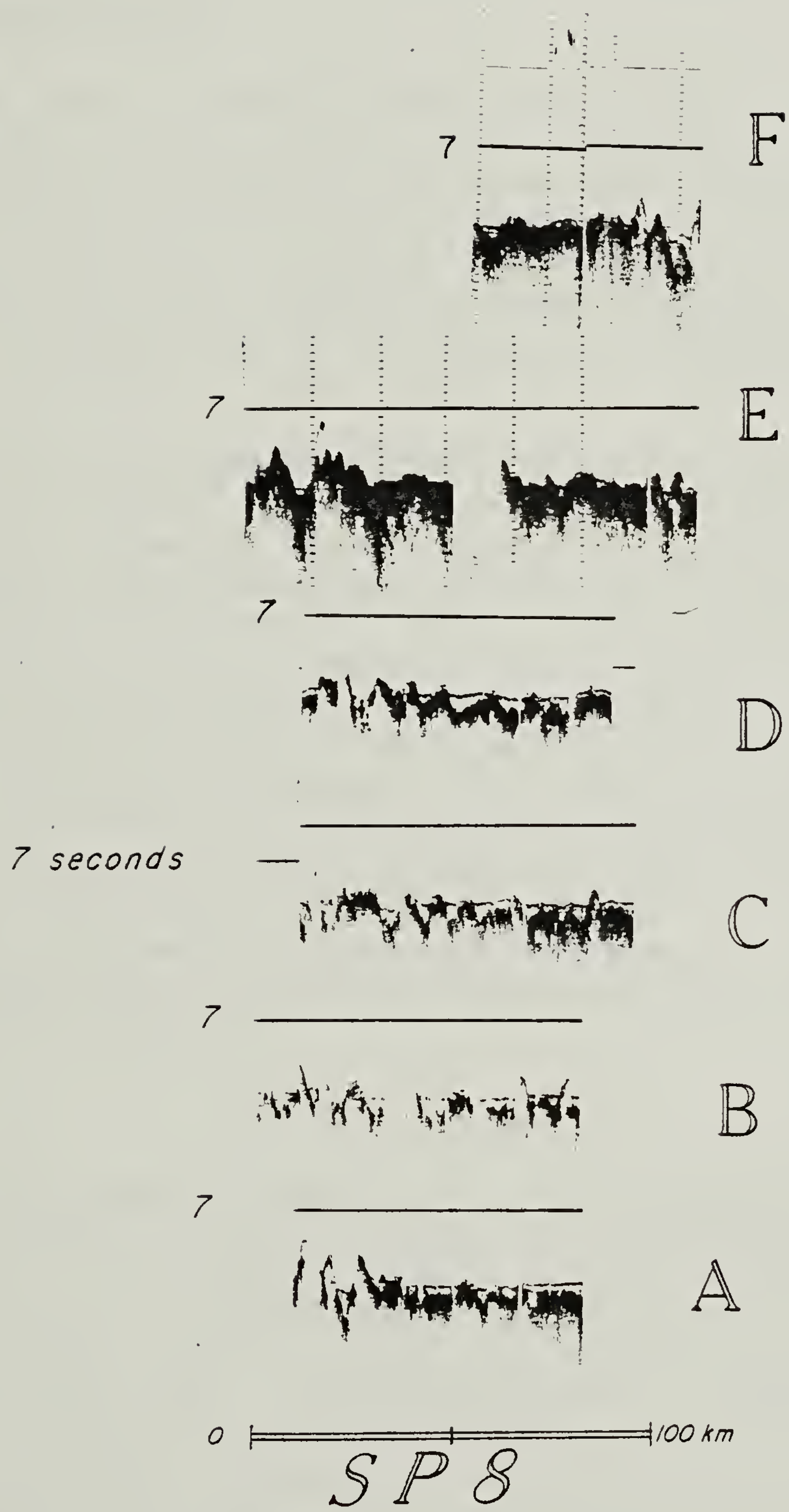


Figure 28

Seismic reflection profiles along lines trending 0.5. Note that the sedimentary surface is not conformable to the basement topography.

50 m of Late Oligocene nannofossil ooze. Beneath this sequence is an 80 m thick layer of Early Oligocene to Late Eocene volcanic silts (Ingle, Karig and White, 1975). These silts probably form the opaque layer seen in Profile A below the more transparent layers. The basement was not reached, but a volcanic breccia drilled at the bottom of the hole suggested that it was nearly reached. The basement age was estimated to be Late Eocene.

Seismic Refraction Studies

This is an area of unusually deep water (6000 m) for an oceanic basin estimated to be 40 to 50 m.y. old. The sonobuoys were run along lines that trend roughly 285 to correspond to the principal topographic trends. Along two profiles, sonobuoys 17 and 18, a refractor from Layer 3 was observed with velocities of 6.6 and 7.0 km/sec respectively. A refractor from Layer 2 was discerned at only one station, sonobuoy 17, which indicated a velocity of 5.4 km/sec. A Layer 2, with a velocity of 5.0 km/sec was assumed at the other sites. The Layer 2 - Layer 3 interface lies at about 7.4 km (Figure29).

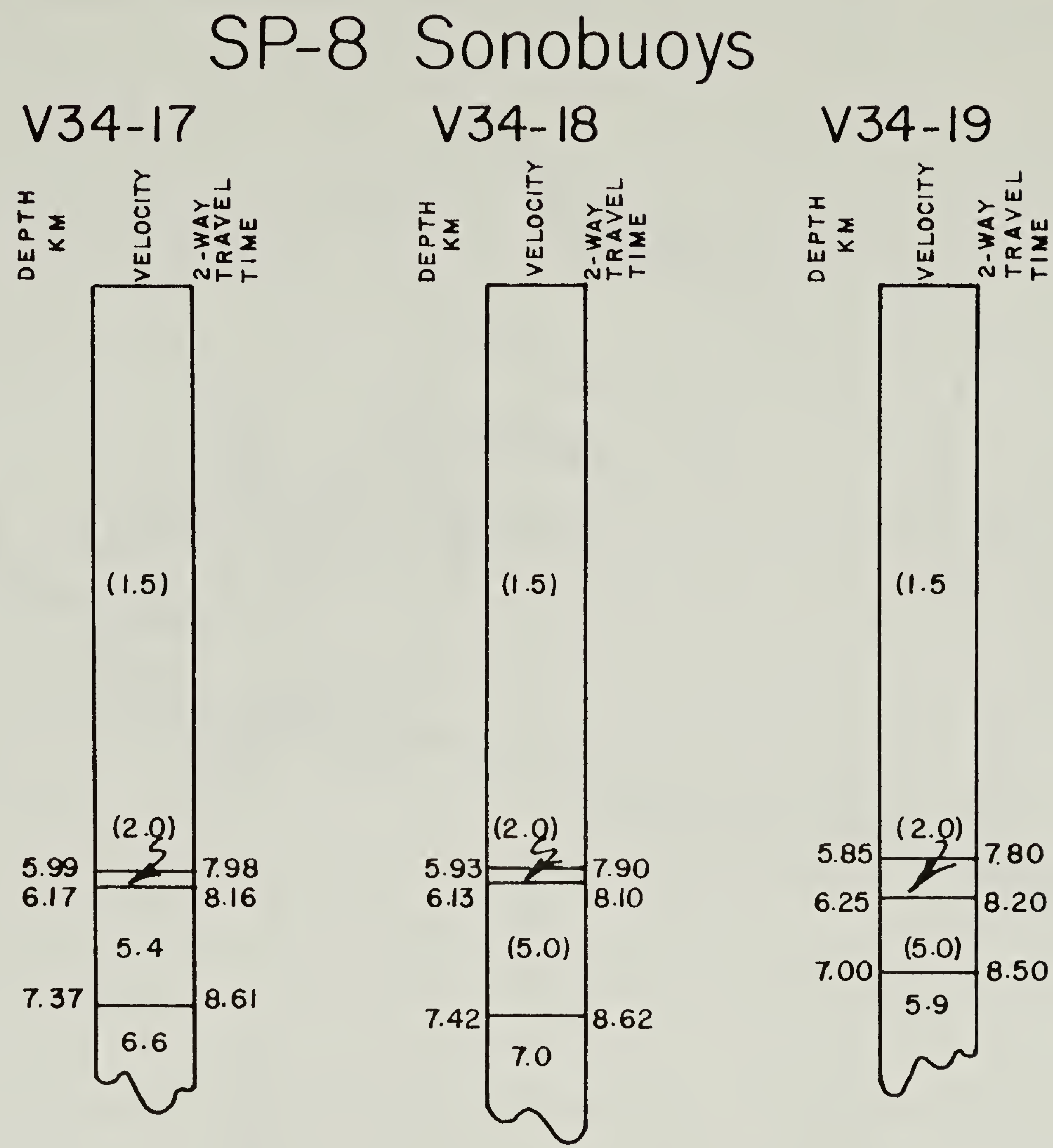
An ocean bottom seismometer (OBS) refraction experiment was attempted at this site. Three bottom seismometers were dropped in a triangular array. Their positions are shown in Figure 26 as OBS, A, B and C. For several reasons, no useful results have been received from this experiment. Firstly, OBS B released early and came back to the surface shortly after reaching the bottom. No shots were recorded on this instrument while it was on the bottom. Secondly, OBS C recorded many bottom shots, but no time trace was recorded due to a malfunction of that part of the instrumental system. Consequently, the data are useless. Only OBS A operated normally. Thirdly, there was difficulty in getting the explosives to detonate at charge sizes greater than 16 lbs , because of undersized caps and very old explosive blocks. Most of the TNT dated from 1943. Lastly, there is no adequate playback equipment with which to analyze the data. It is possible that at some future date refractors recorded at OBS A will be analyzed to give velocities at this site.

Magnetics

A prominent anomaly trending 285° is clearly defined and adds strength to the anomalies already detected on CONRAD 17-11 and VEMA 28-14 cruises, Figure 30. The anomaly pattern of the West Philippine Basin has been analyzed by Watts, Weissel and Larson, 1977 and by Lauden, 1976. Both have identified this prominent anomaly as the oldest edge of Anomaly 20 of the Tertiary time scale. An alternative is to identify it with the edge of Mesozoic Anomaly M3, Larson and Hilde, 1975. The results of DSDP drilling dating the Philippine basement as Tertiary seem to mitigate against a Mesozoic age. Hence, the identification of the anomaly with the Tertiary Anomaly 20 seems to be the most acceptable. This would place the age at 46 m.y., or Middle Eocene, in reasonable agreement with the results at DSDP Site 290.

Heat-Flow Results

Three heat-flow measurements were made in the northeast corner of the survey area. The measurements shown in Figure 3l were placed close together



Solutions to three sonobuoys shot at Site #8.

Figure 29

Magnetic anomalies plotted along the track.

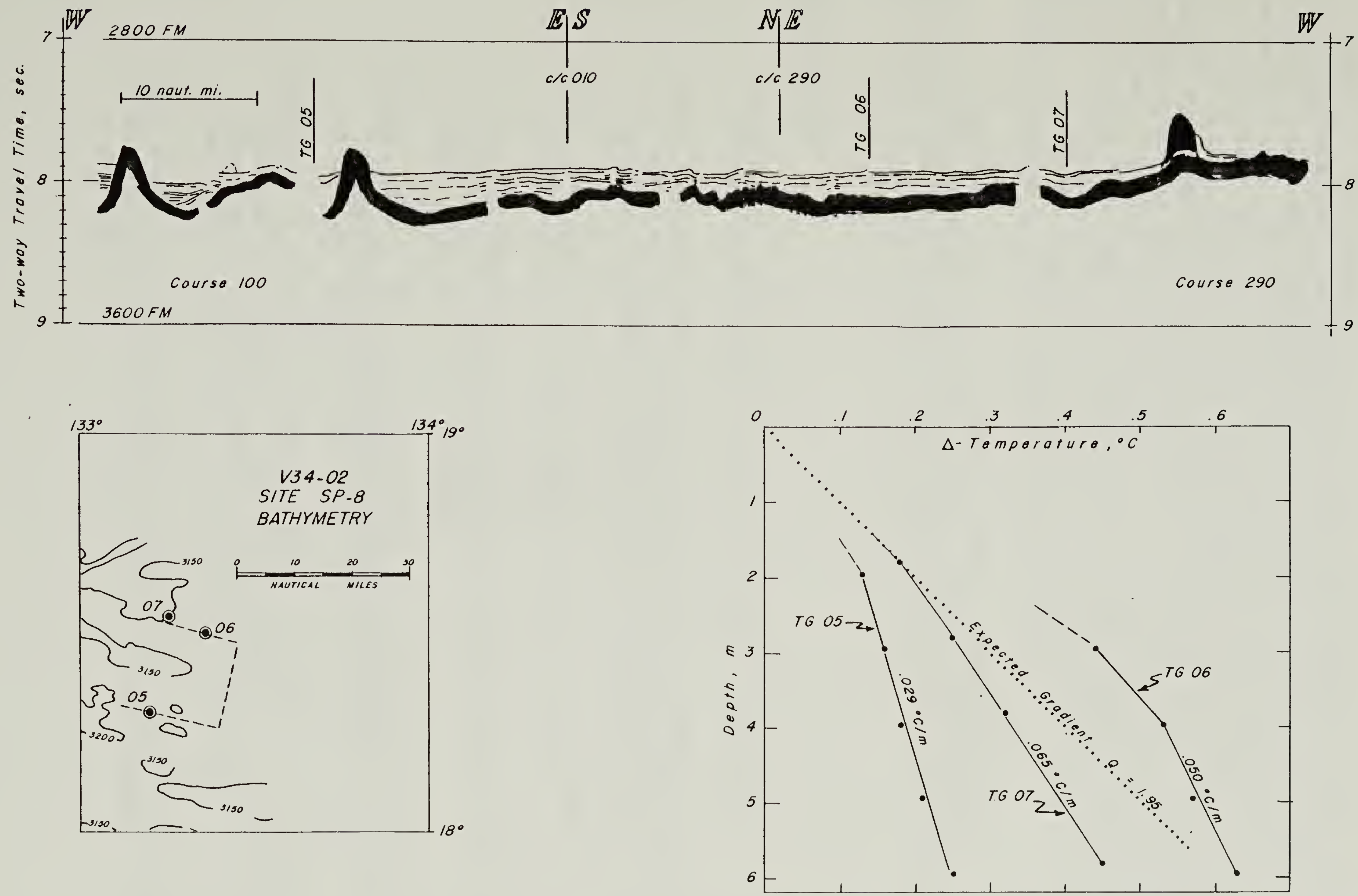


Figure 31

Temperature profile measurements in the West Philippine Basin.

to look for local variations of heat flow. This part of the area surveyed has relatively thick sedimentary deposits, as noted earlier, and we would expect the conductive heat-flow values to be the most representative here. The temperature profiles in the lower right hand corner of Figure 31 show the three temperature profiles to a depth of 6 m. The lower parts of these profiles define widely varying gradients even though the sedimentary cover, especially at stations 6 and 7, is thick and complete. In addition, the gradient is not uniform with depth, but decreases with depth at all stations. These results can be explained if we assume that there is a vertical flux of water through the sediment. At present, there is no other feasible way to explain these results. If the interpretation is correct, it implies that there is active circulation of water through the oceanic crust.

Notice that none of the stations yielded a temperature gradient close to that expected over crust 46 m.y.; however, when the heat carried by the flux of water is taken into account, the values obtained are quite close to the theoretically predicted value.

References

Fischer, A.G., B.A. Heezen et al. (1970) Geological history of the Western North Pacific; Science, v. 168, p. 1210-1214

Ingle, J.C., D.E. Karig and S.M. White (1975) Introduction and explanatory notes; in, Initial Reports of the Deep-Sea Drilling Project (U.S. Government Printing Office, Washington, D.C.), v. 31,

Karig, D.E. (1971) Structure history of the Mariana Island Arc System; Bull. Geol. Soc. Amer., v..82, p. 323-344

Larson, R.L. and R.W.C. Hilde (1975) A revised time scale of magnetic reversals for the Early Cretaceous and Late Jurassic; Jour. Geophys. Res., v. 80, n. 17, p. 2586-2594

Lauden , K.E. (1976) Magnetic anomalies in the West Philippine Basin, in, Geophysics of the Pacific Basin and Its Margin, ed. G.H. Sutton et al., Am. Geophys. Union, Wash., D.C., v. 19, p. 253-267

Murauchi, S., N. Den, S. Asano, H. Hotta, T. Yoshii, T. Asanuma, K. Hagiwara, K. Ichikawa, T. Sato, W.J. Ludwig, J. I. Ewing, N.T. Edgar and R. E. Houtz (1968) Crustal structure of the Philippine Sea; Jour. Geophys. Res., v. 73, n. 10, p. 4143-3171

Watts, A.B., J.K. Weissel and R.L. Larson (1977) Seafloor spreading in marginal basins of the Western Pacific; Tectonophysics, v. 37, p. 167-181